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Zugelder et al.

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(54) **POTHEAD RETAINING SLEEVE SYSTEM, APPARATUS AND METHOD**

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E21B 17/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01R 13/523*** (2013.01); ***E21B 17/028*** (2013.01); ***E21B 43/128*** (2013.01); ***H01R 13/631*** (2013.01); ***H01R 43/005*** (2013.01)

(58) **Field of Classification Search**
CPC H01R 13/6315; H01R 13/523; H01R 13/631; H01R 43/005; E21B 17/028; E21B 43/128
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,158,472 A * 5/1939 Mendenhall G05D 9/12 318/482
2,906,809 A * 9/1959 Drenning H01B 17/306 174/73.1

(Continued)

FOREIGN PATENT DOCUMENTS

KR 200449411 Y1 7/2010

OTHER PUBLICATIONS

PCT Application Serial No. PCT/US2018/016313, International Search Report, dated May 10, 2018, 3 pages.
PCT Application Serial No. PCT/US2018/016313, International Written Opinion, dated May 10, 2018, 8 pages.

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(74) *Attorney, Agent, or Firm* — Gilliam IP PLLC

(57) **ABSTRACT**

A pothead retaining sleeve apparatus, system and method. An electric submersible (ESP) motor pothead includes pivotable retaining sleeves, each pivotable retaining sleeve including a ball that seats within a socket inside the pothead, the ball rotatable in the socket such that each pivotable retaining sleeve is independently moveable around a spheroidal joint formed by the ball and socket. An ESP motor pothead system includes a pothead for electrically connecting a power cable to an electric submersible motor, each phase of the power cable extending through a retaining sleeve, the retaining sleeve extending through a conduit formed through an insulating block inside the pothead, the conduit including a spherical socket, the retaining sleeve including a tubular portion terminating at a ball seated

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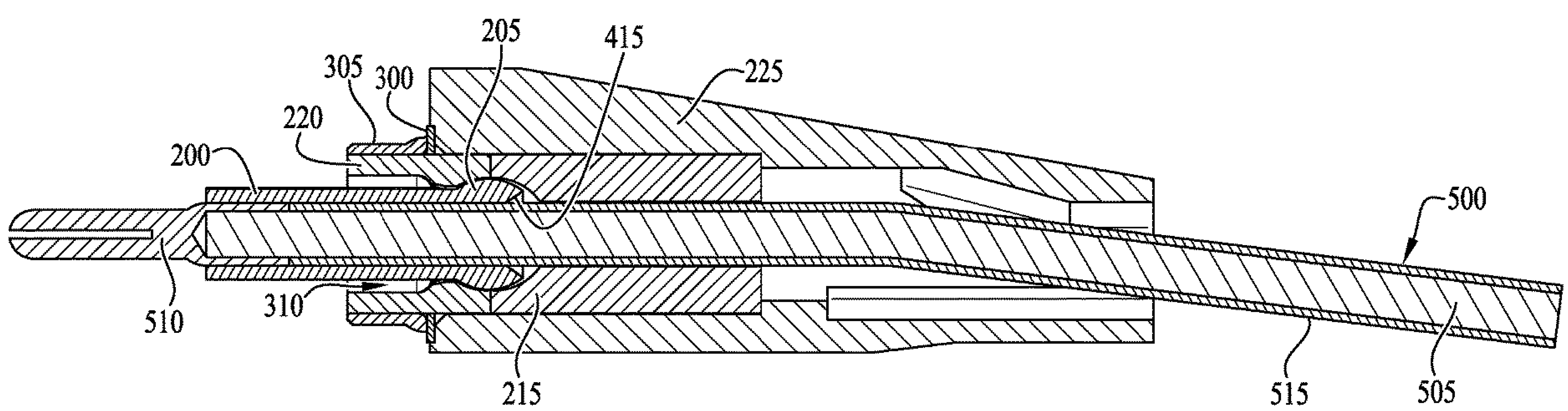

within the spherical socket to form a ball and socket joint, and the tubular portion rotatable around the ball and socket joint during tying off of the phases.

20 Claims, 14 Drawing Sheets

(51) **Int. Cl.**
E21B 43/12 (2006.01)
H01R 13/631 (2006.01)
H01R 43/00 (2006.01)

(58) **Field of Classification Search**
USPC 439/246
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,999,998	A *	9/1961	Cole	H01R 13/6315 439/252
5,334,035	A *	8/1994	Wehrle	H01R 13/422 439/246
8,029,317	B2 *	10/2011	Albers	E21B 17/023 439/589
2011/0130020	A1	6/2011	Costa et al.	
2011/0176941	A1	7/2011	Albers et al.	
2012/0052721	A1	3/2012	Watson	
2016/0093963	A1	3/2016	Streckewald	
2018/0090874	A1 *	3/2018	Frey	H01R 43/005
2018/0163728	A1 *	6/2018	Zugelder	E21B 43/12
2019/0072090	A1 *	3/2019	Straub	F04C 2/101

* cited by examiner

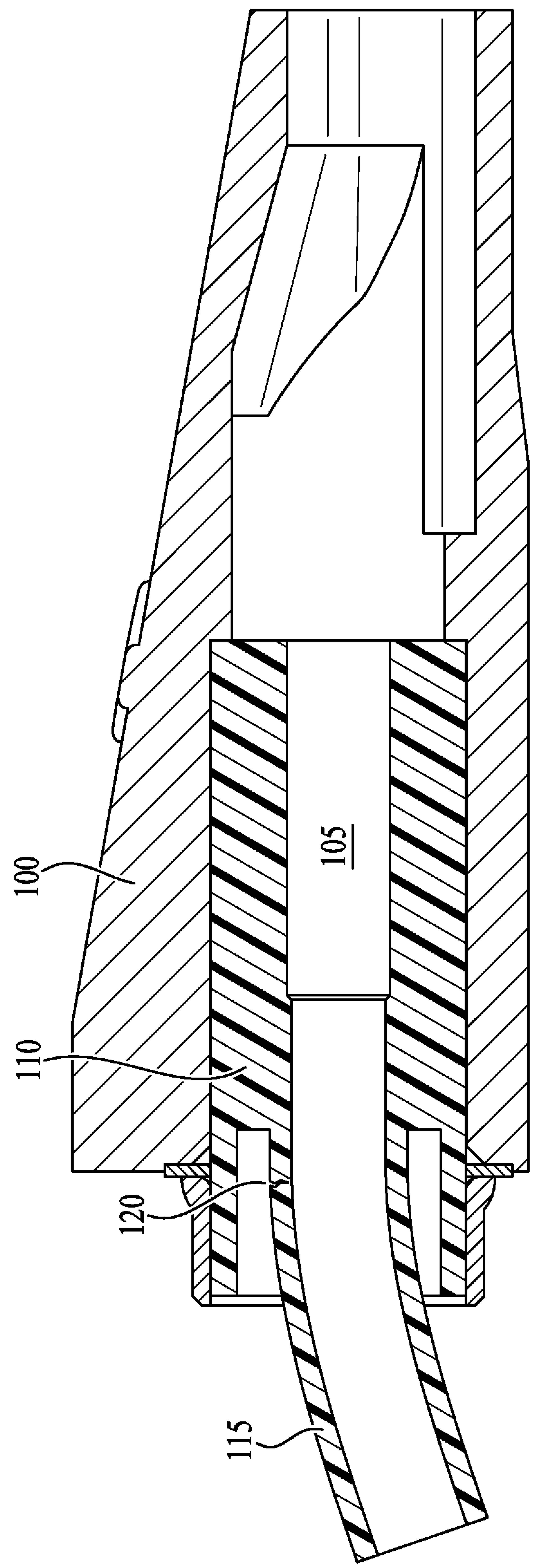

FIG. 1
PRIOR ART

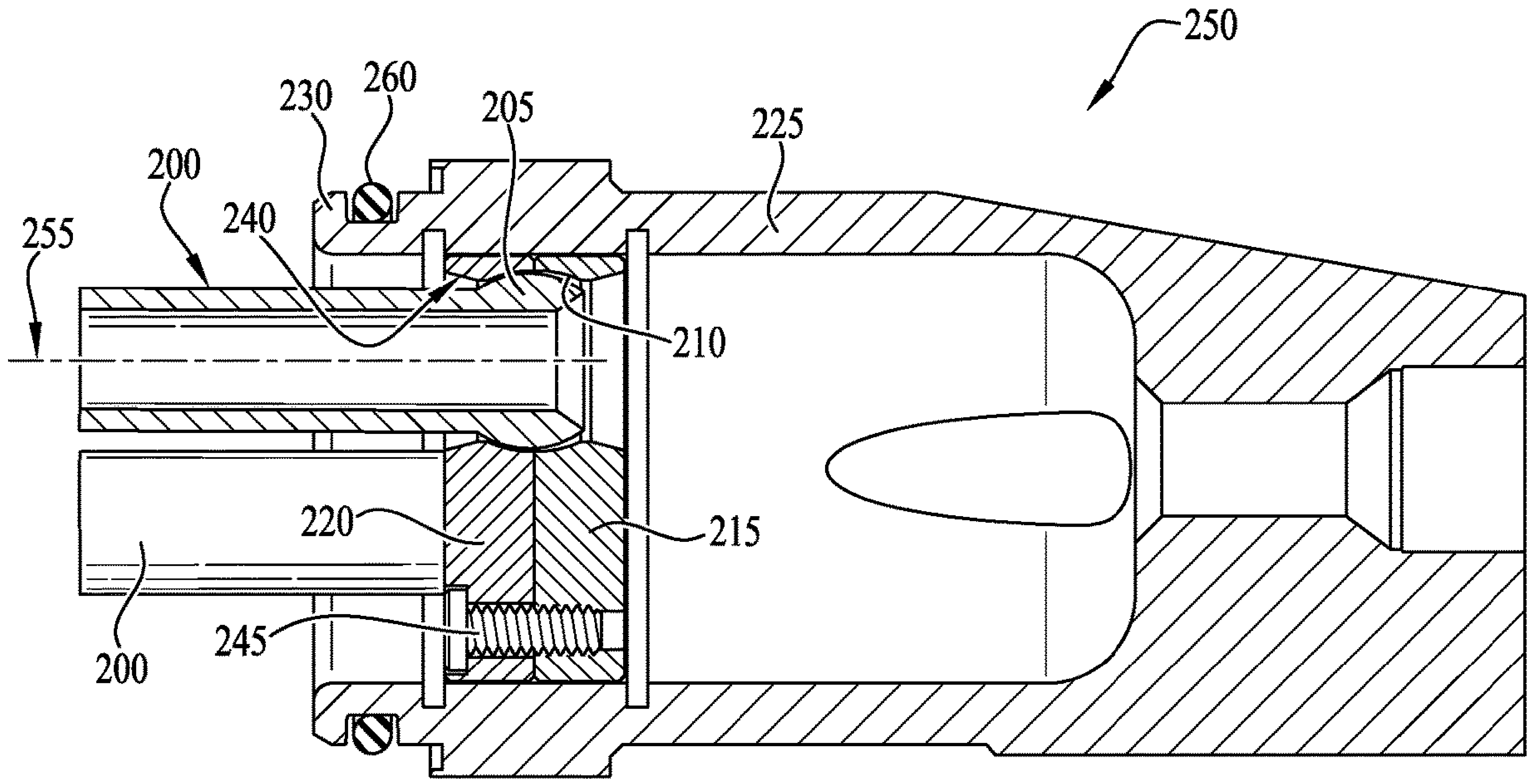
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FIG. 2A

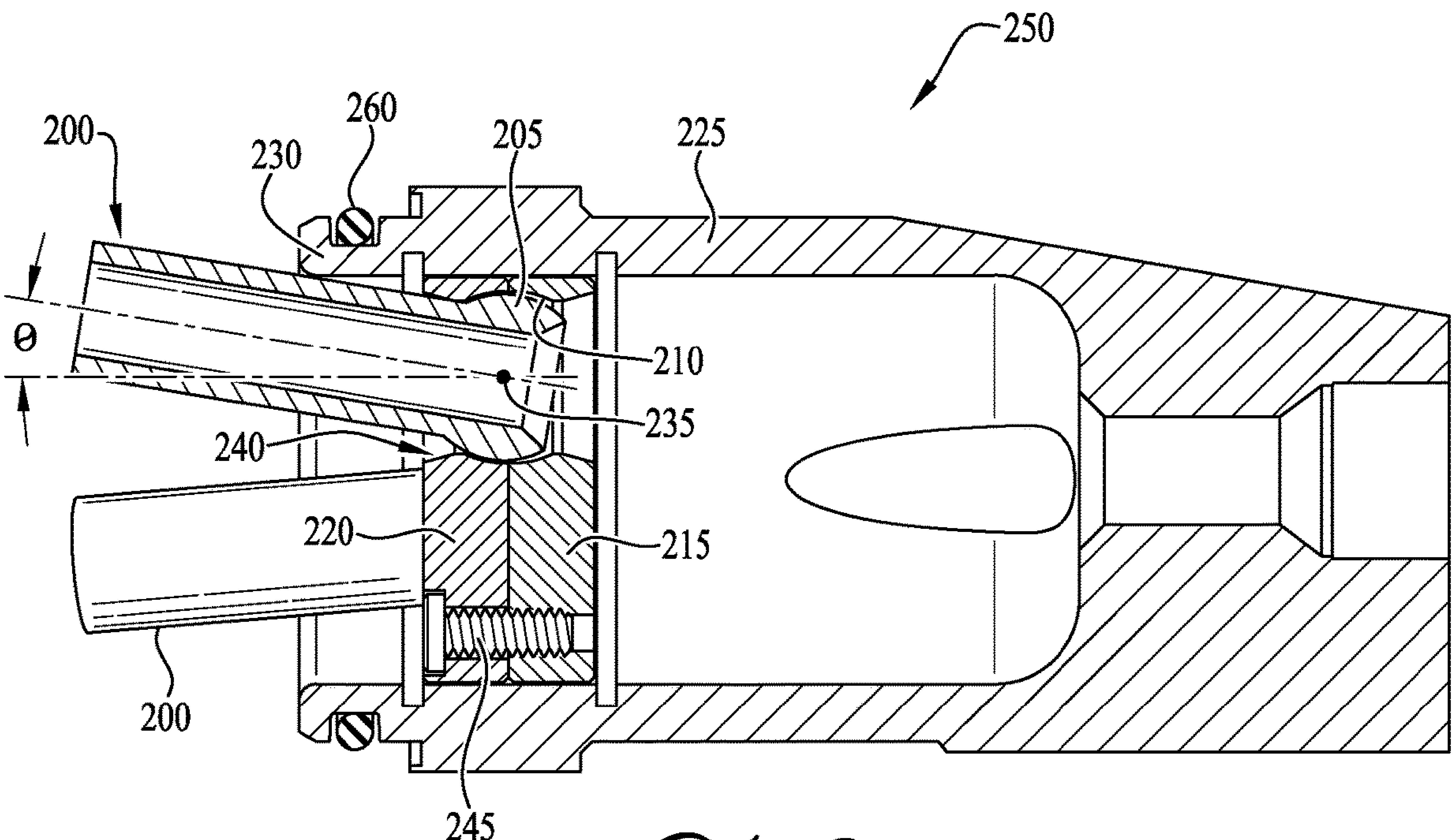
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FIG. 2B

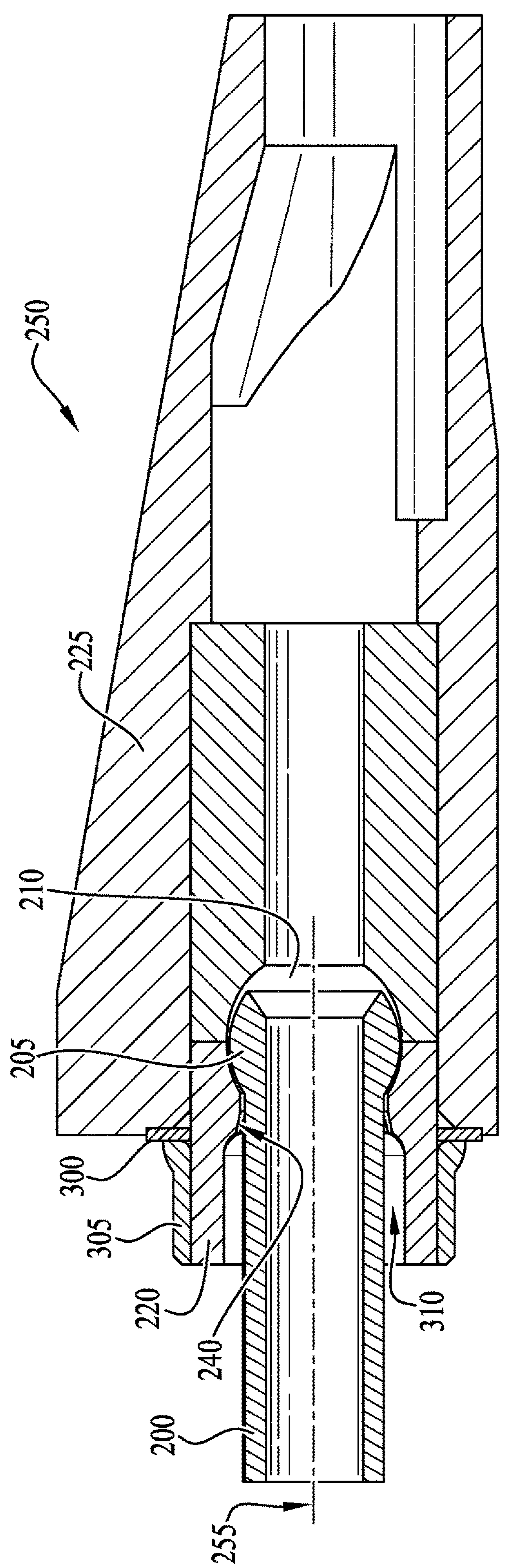
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FIG. 3A

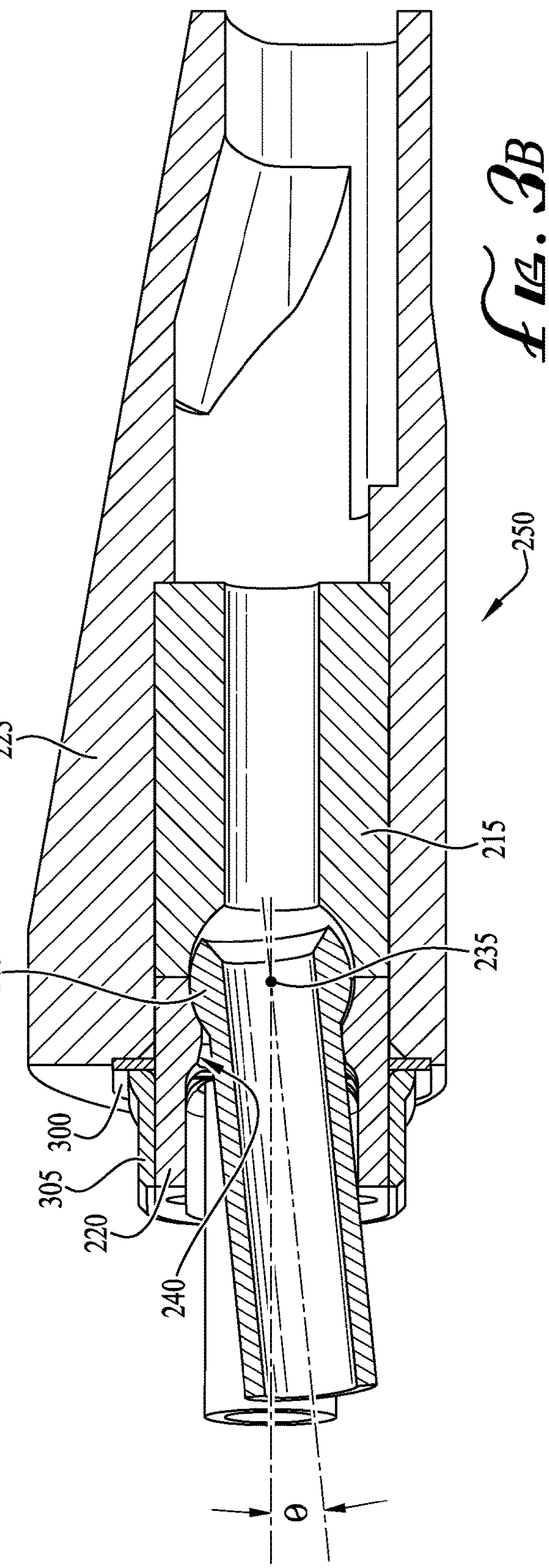
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FIG. 3B

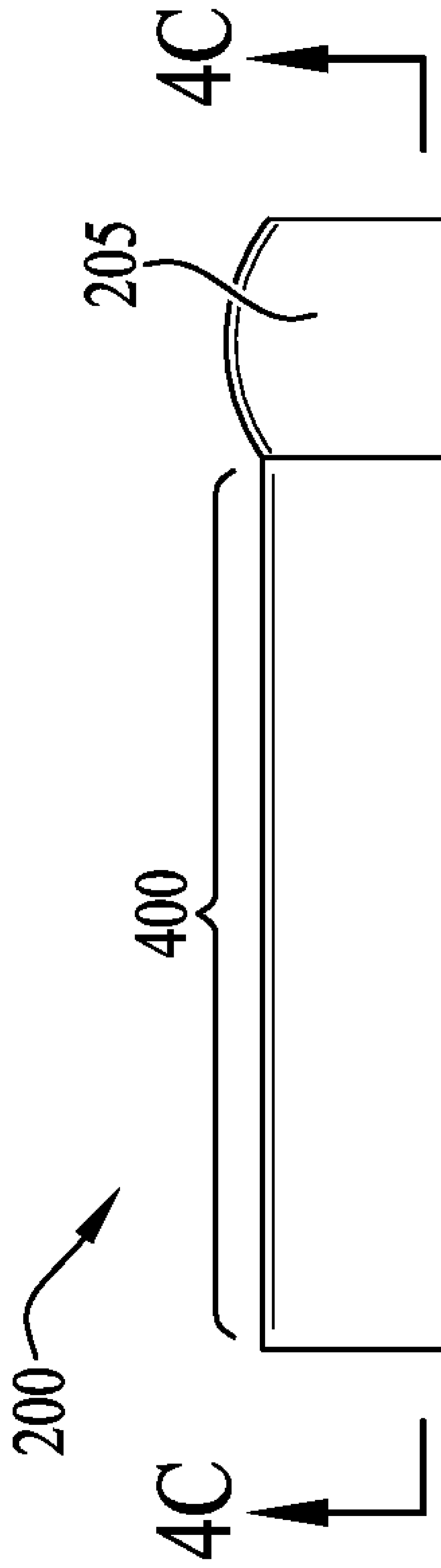

FIG. 4A

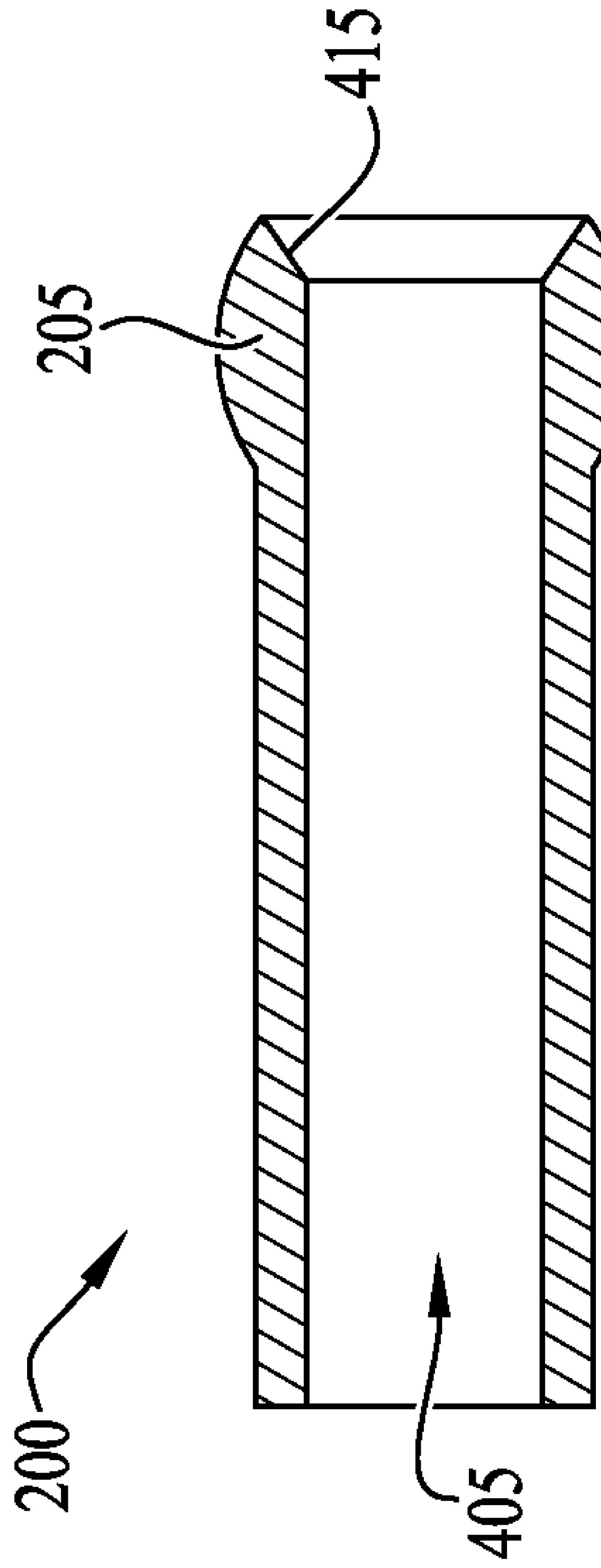

FIG. 4C

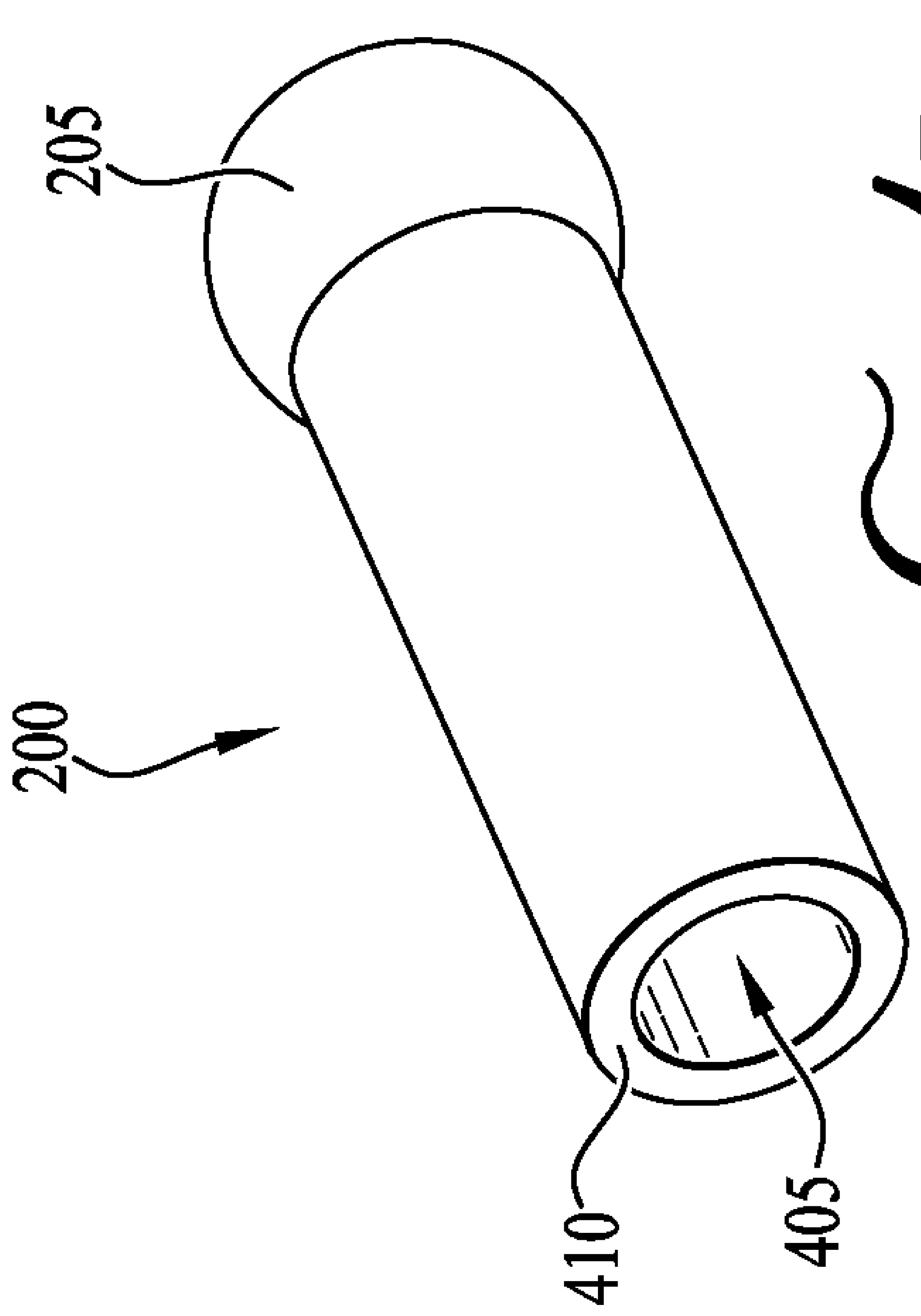

FIG. 4B

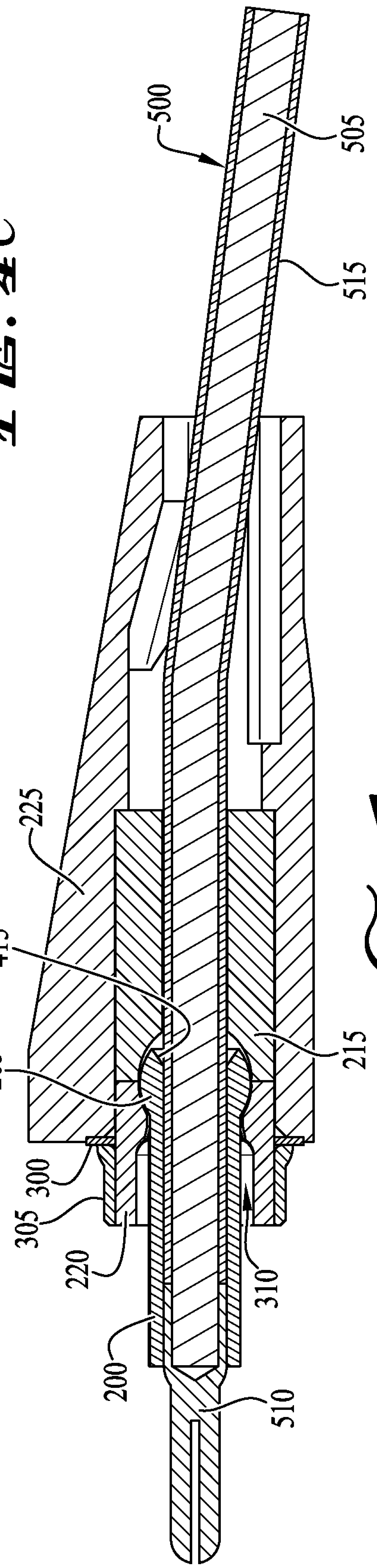

FIG. 5

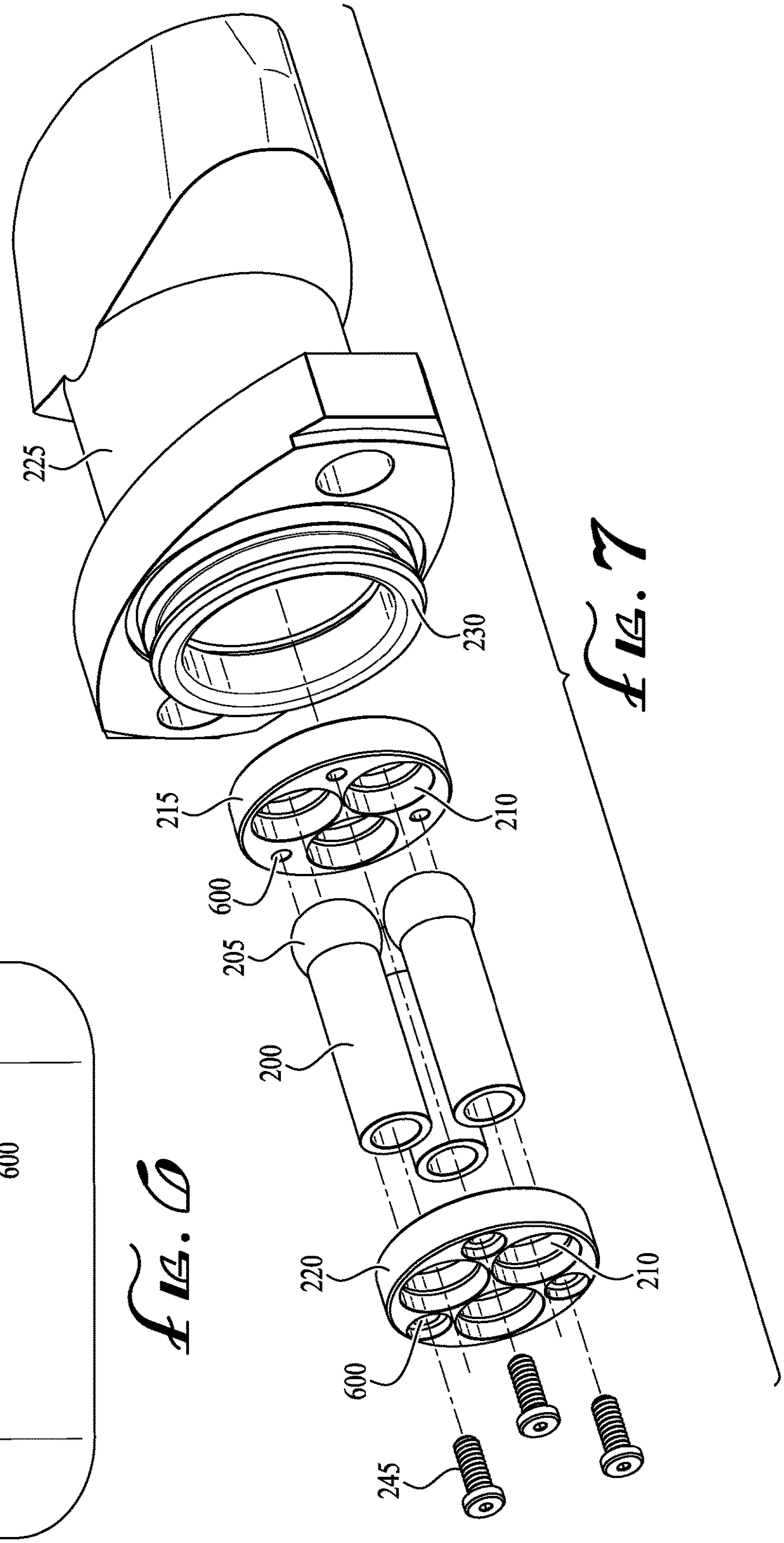
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FIG. 7

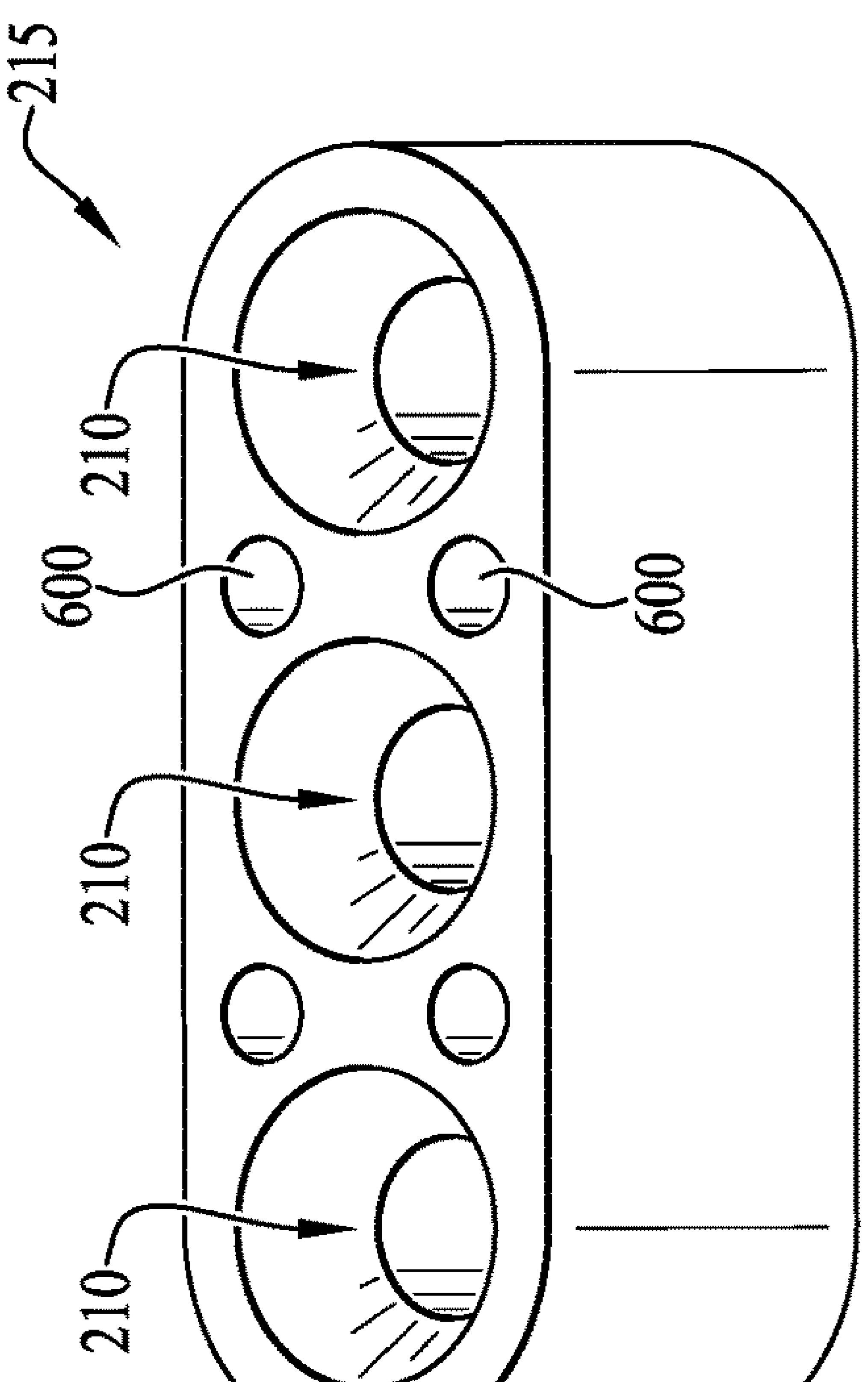
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FIG. 6

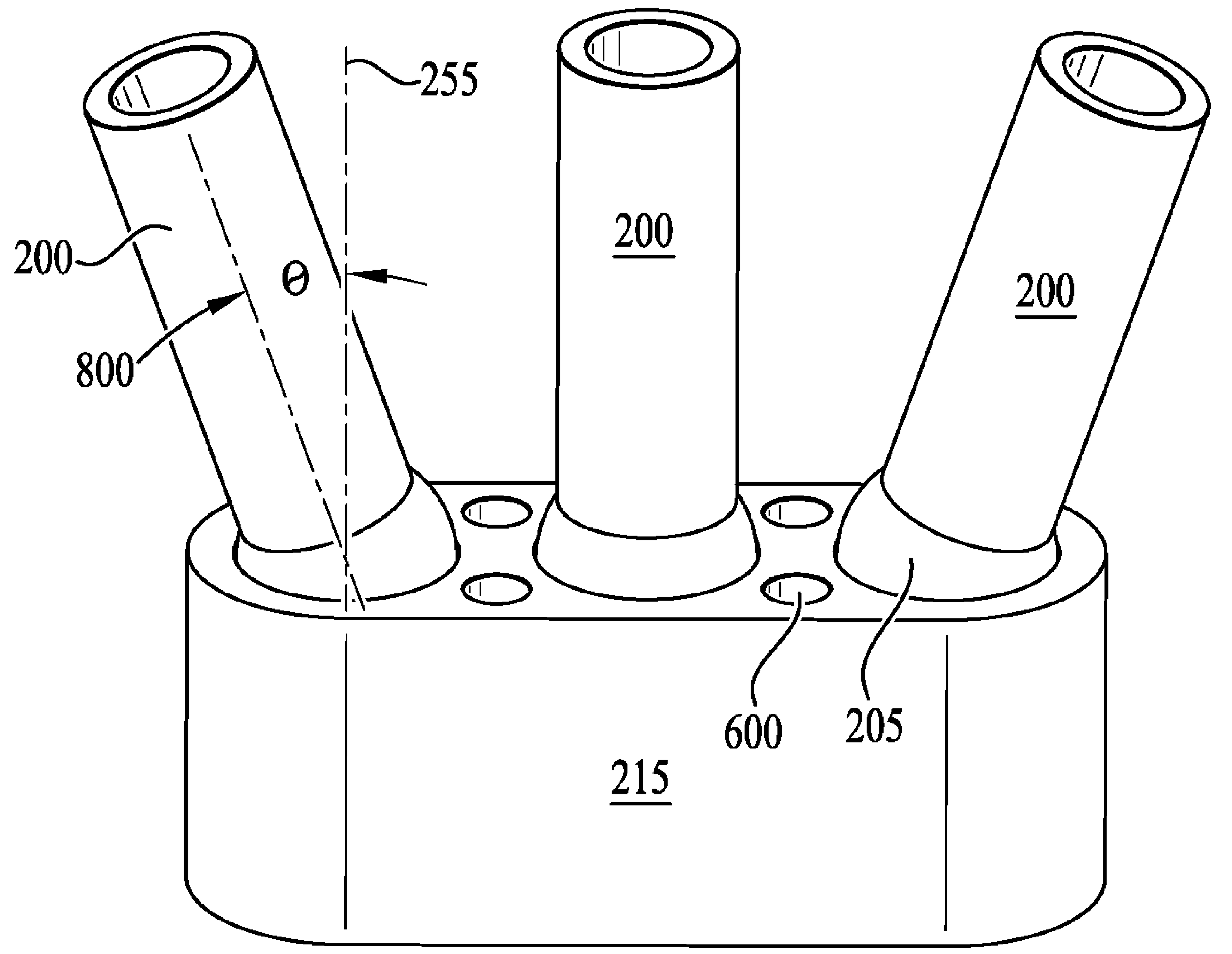
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FIG. 8

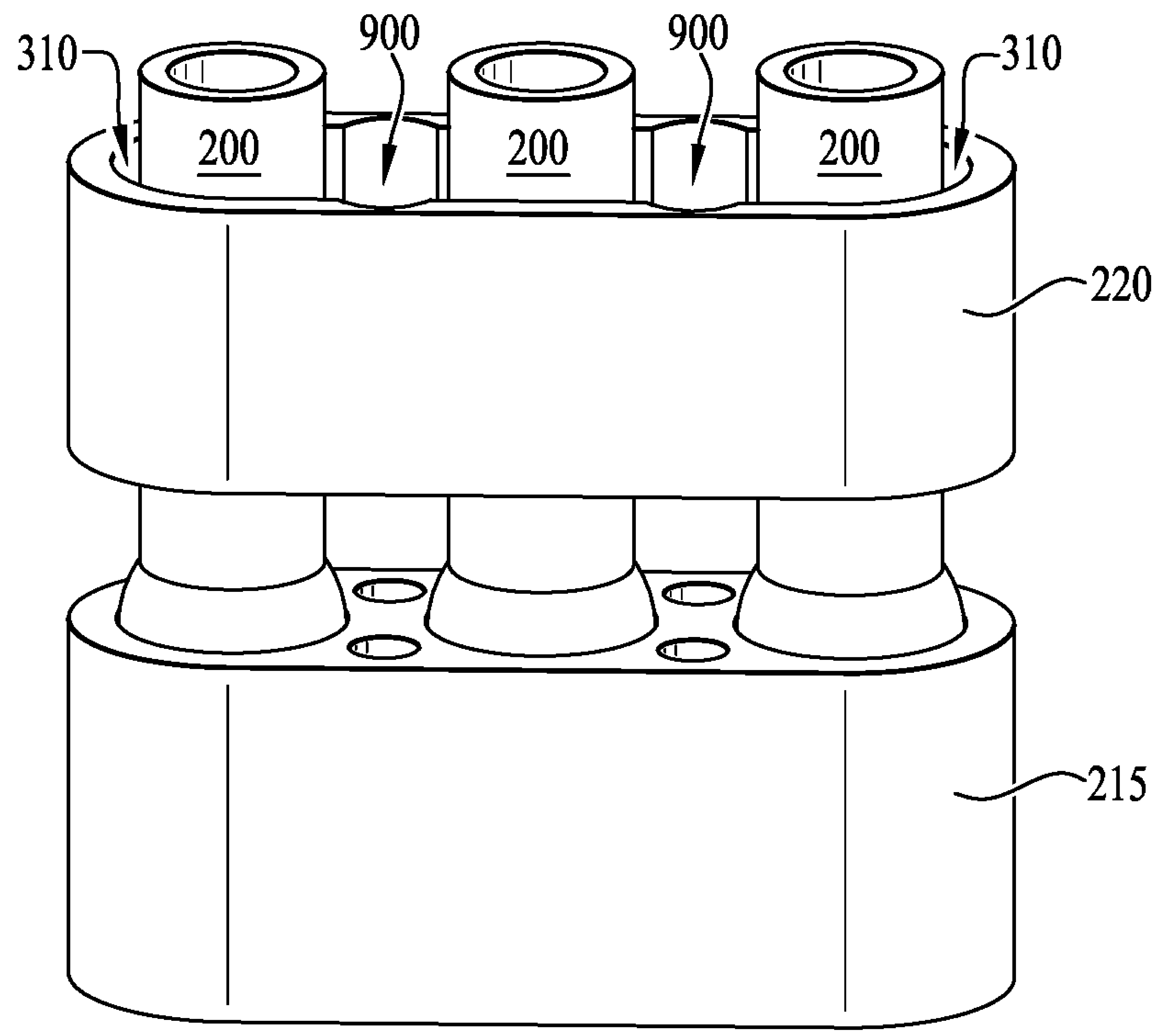
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FIG. 9

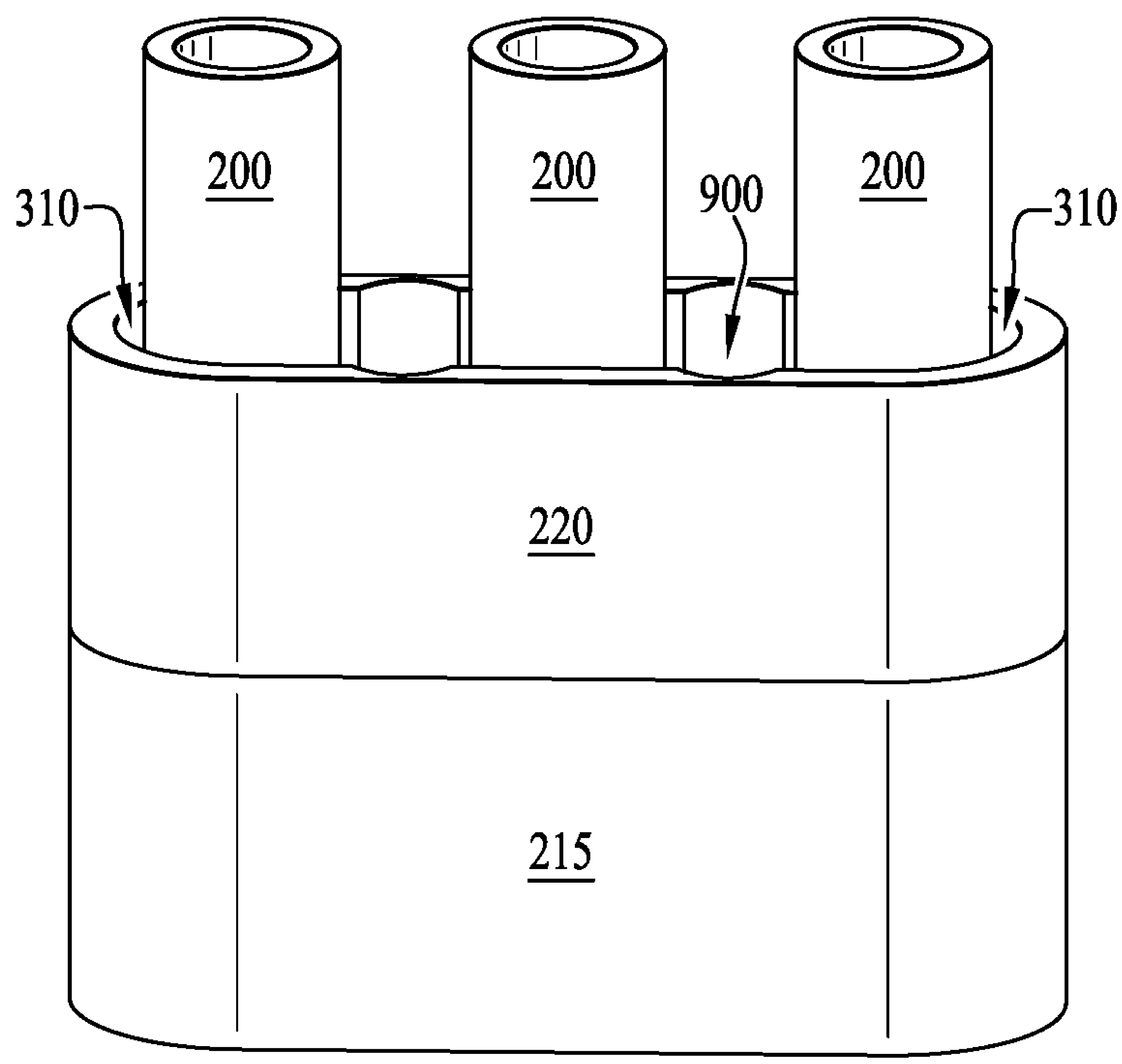
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FIG. 10

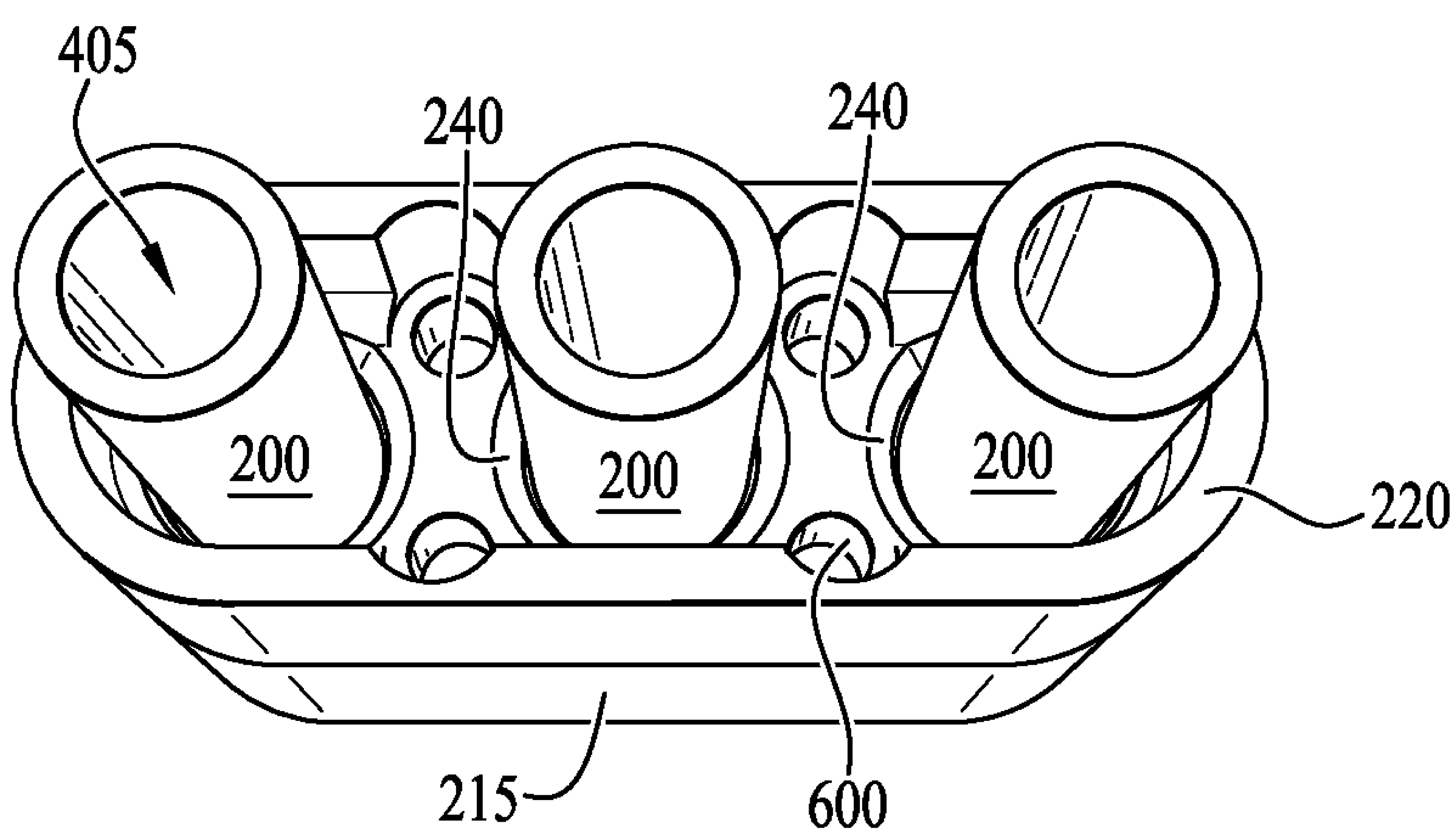
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FIG. 11

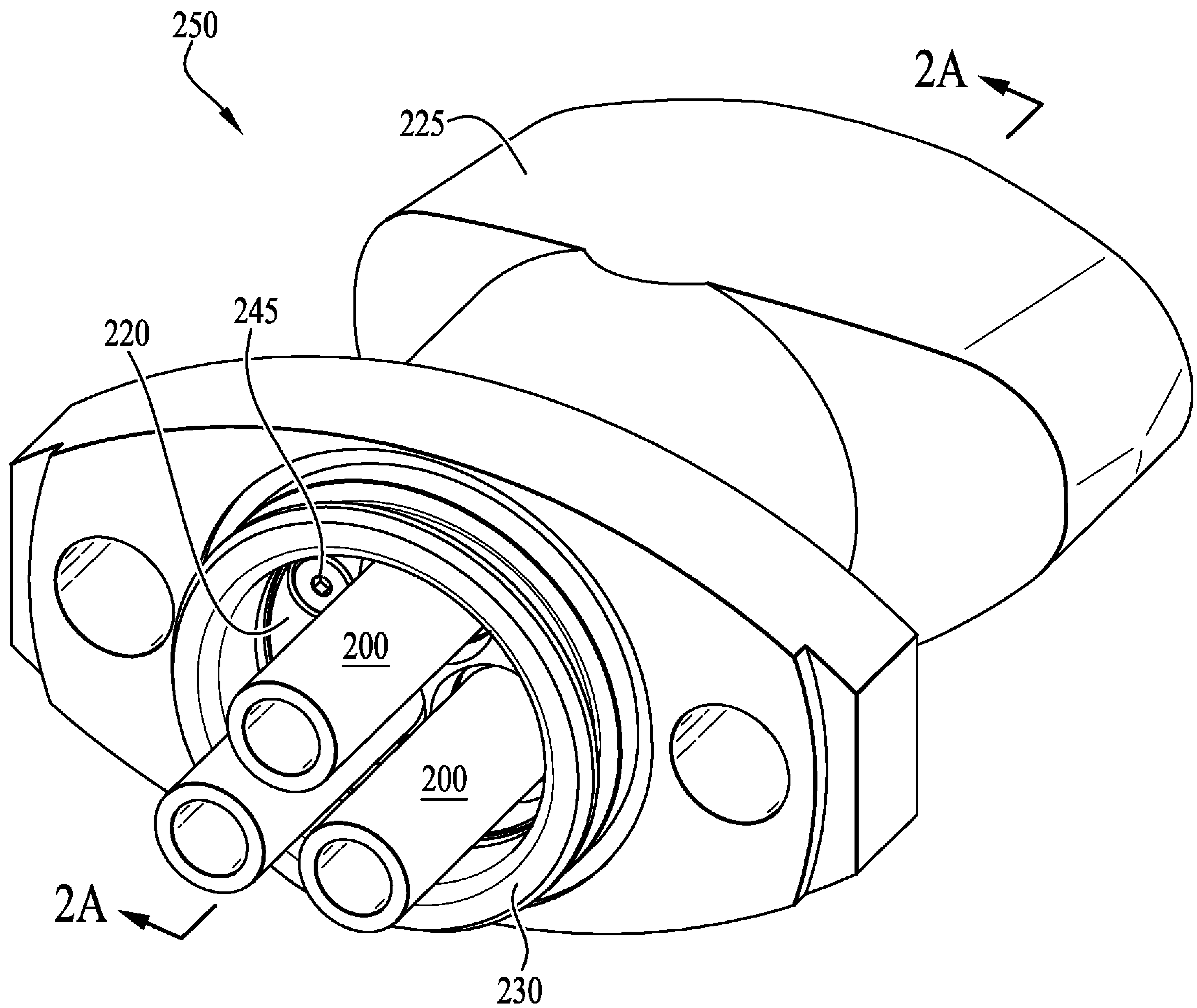

FIG. 12

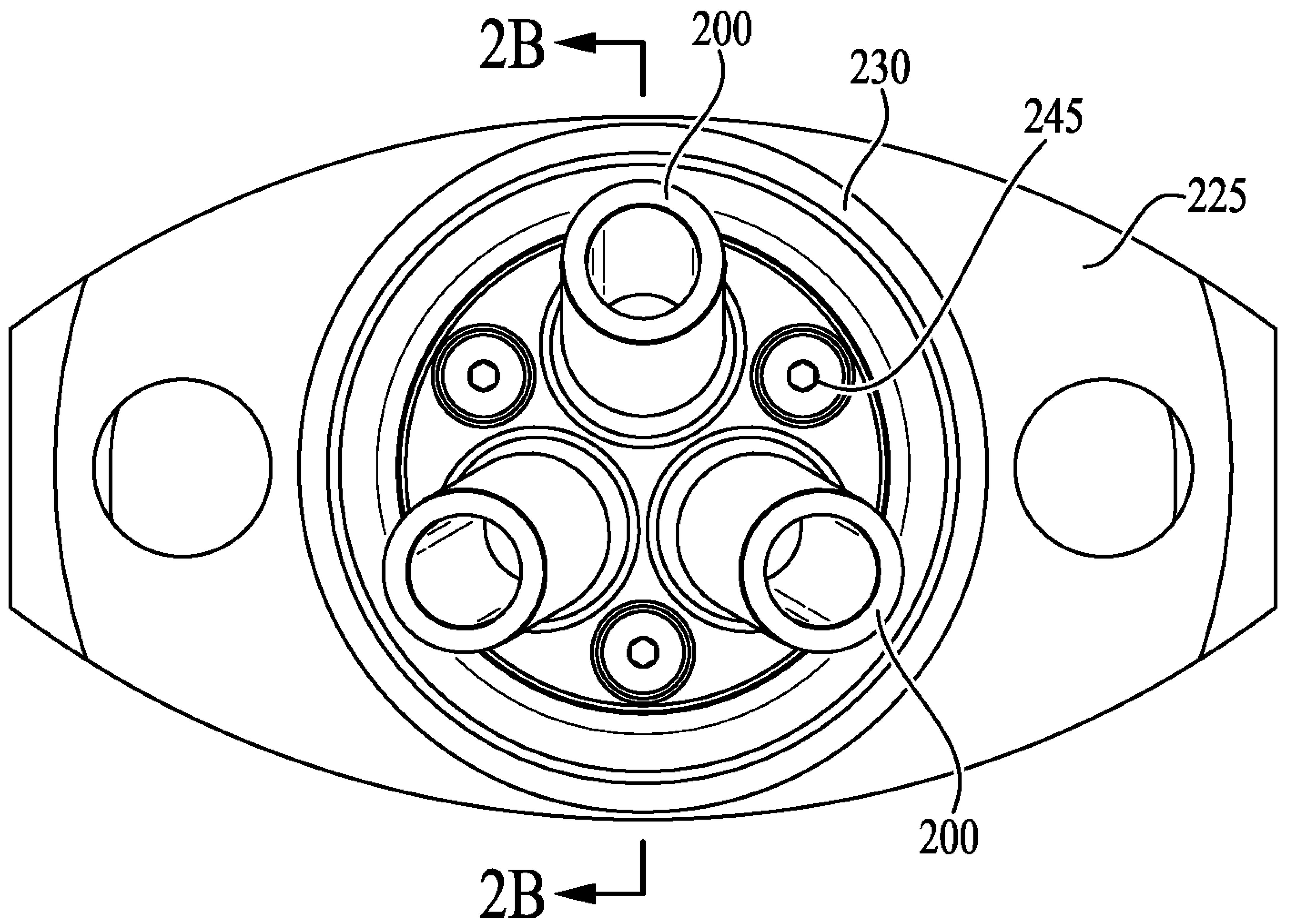

FIG. 13

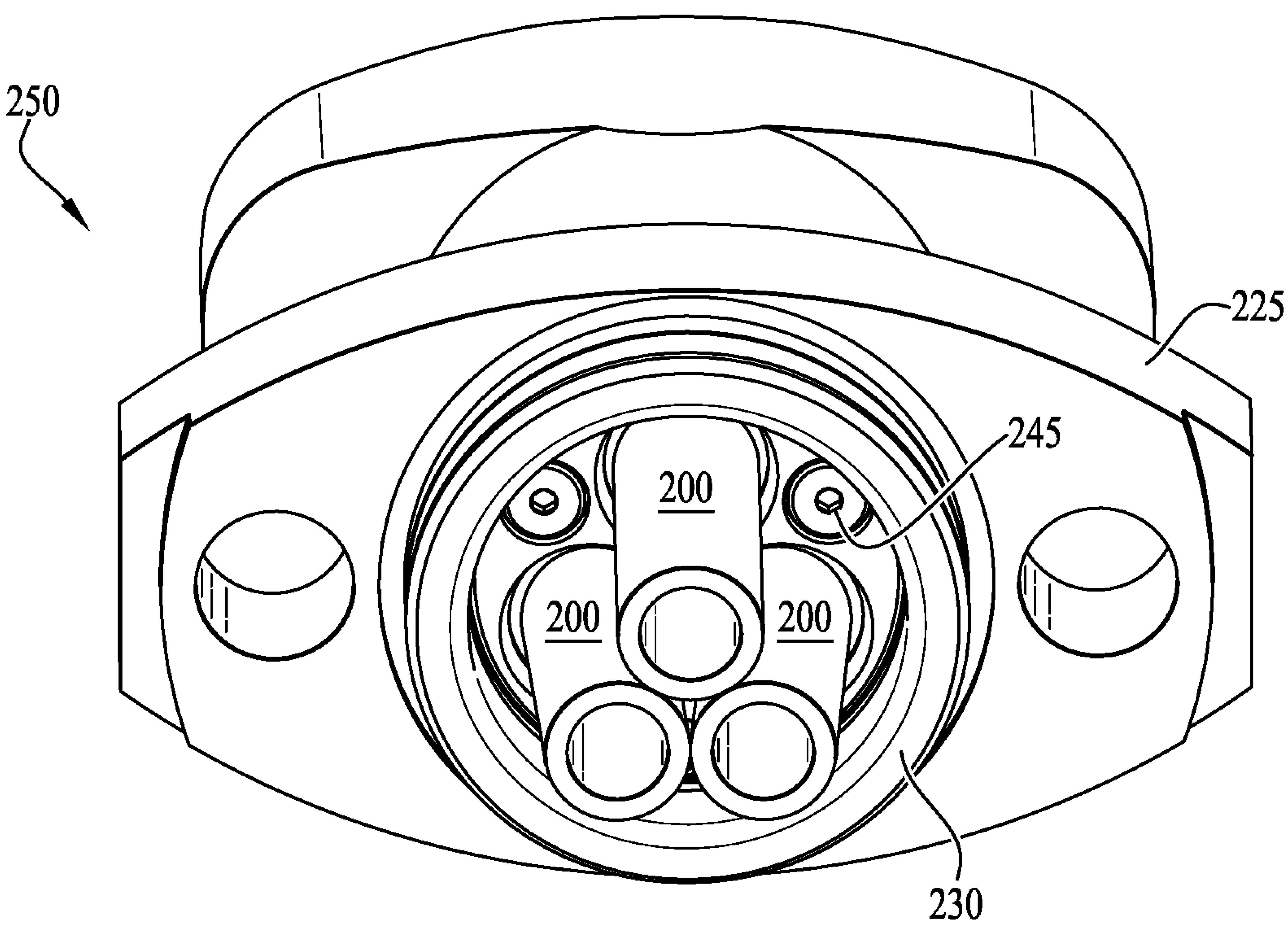

FIG. 14

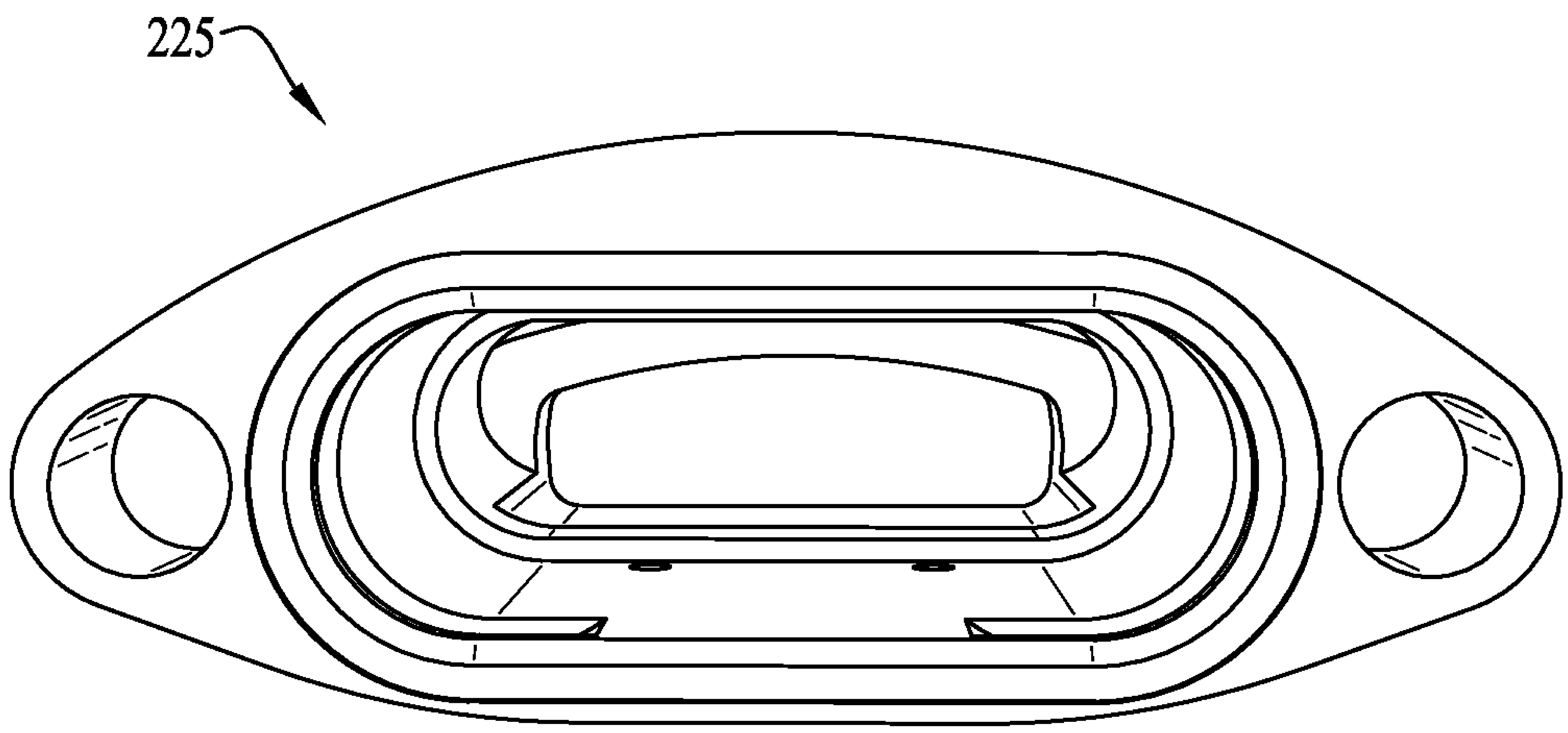

FIG. 15A

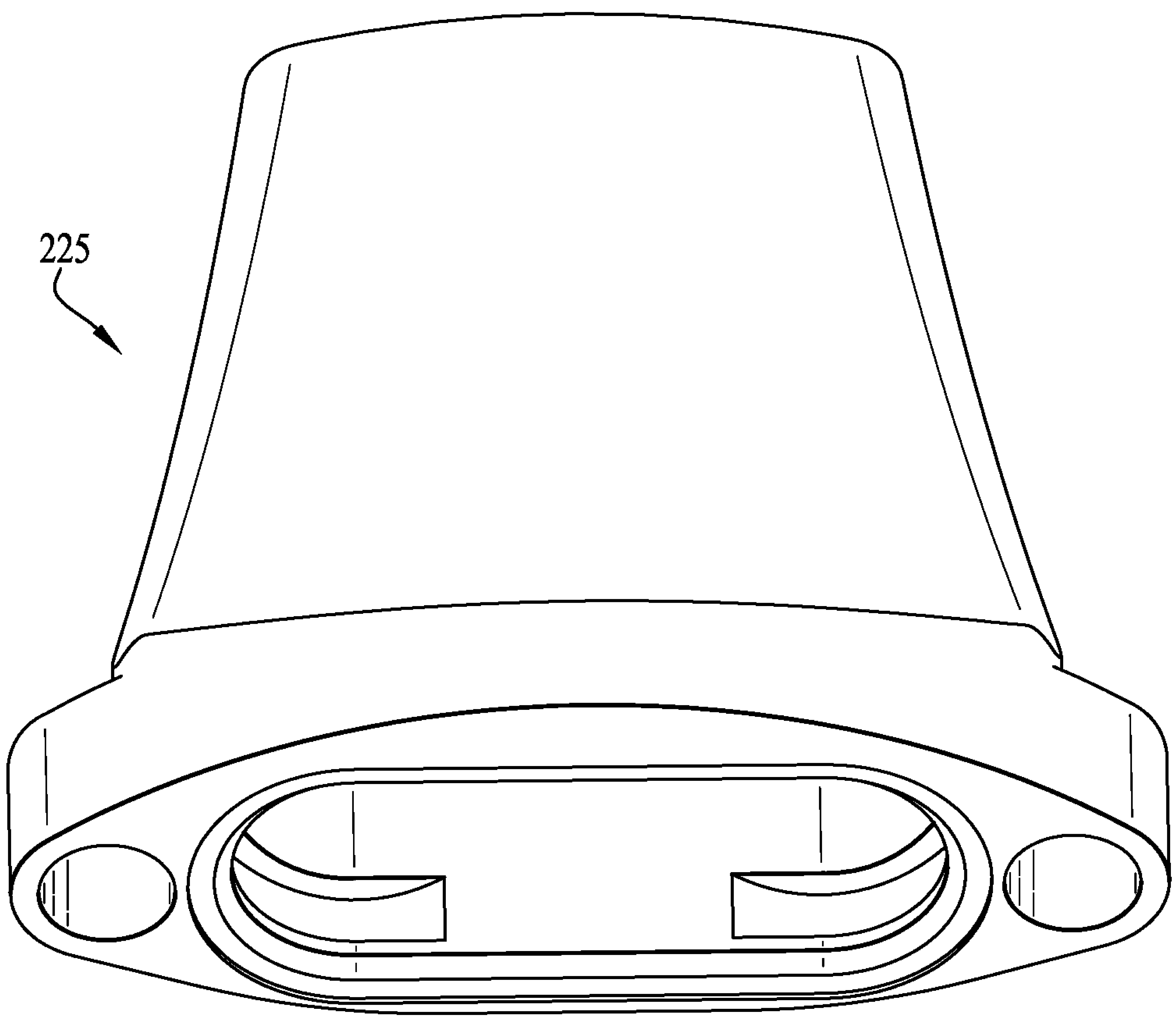

FIG. 15B

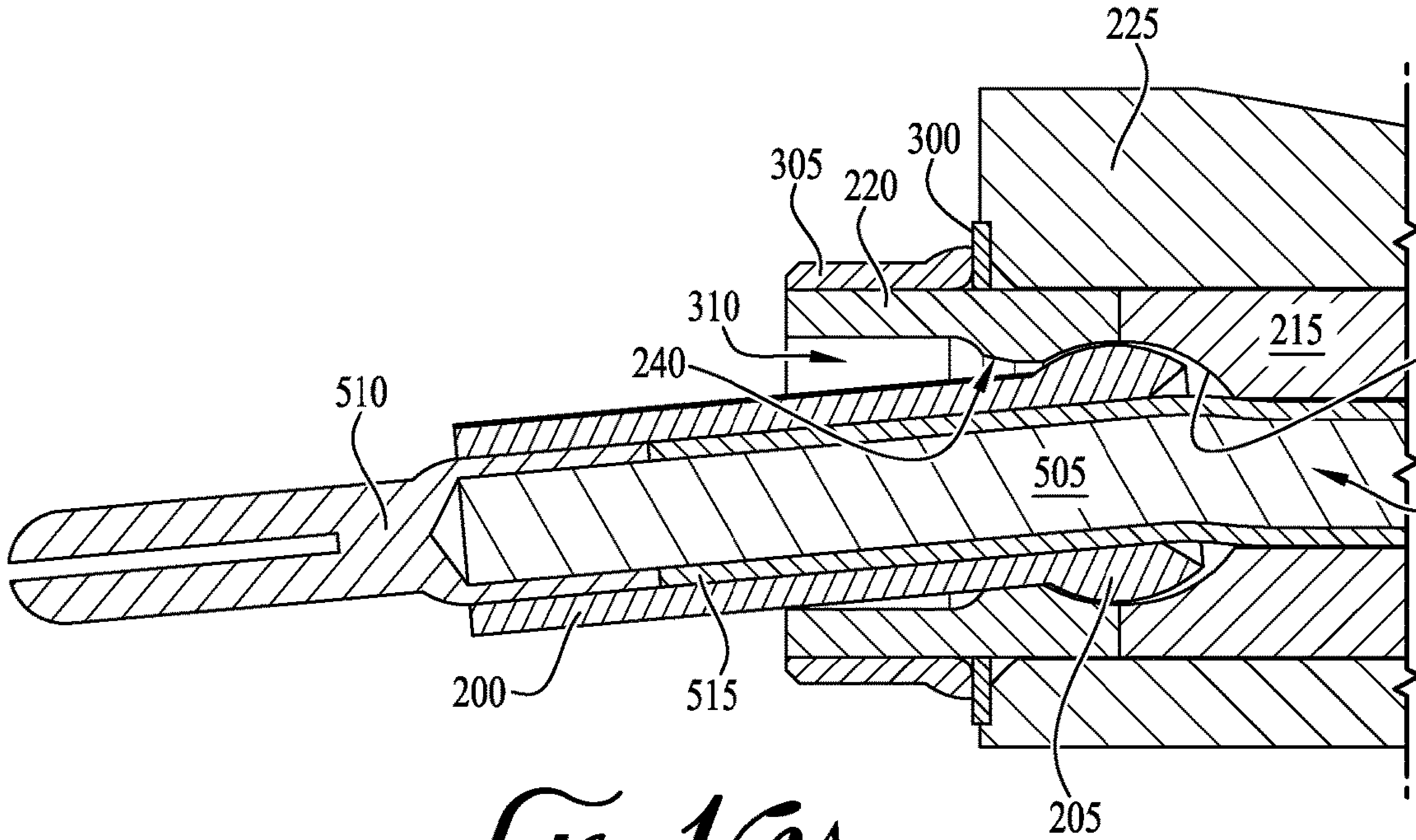

FIG. 16A

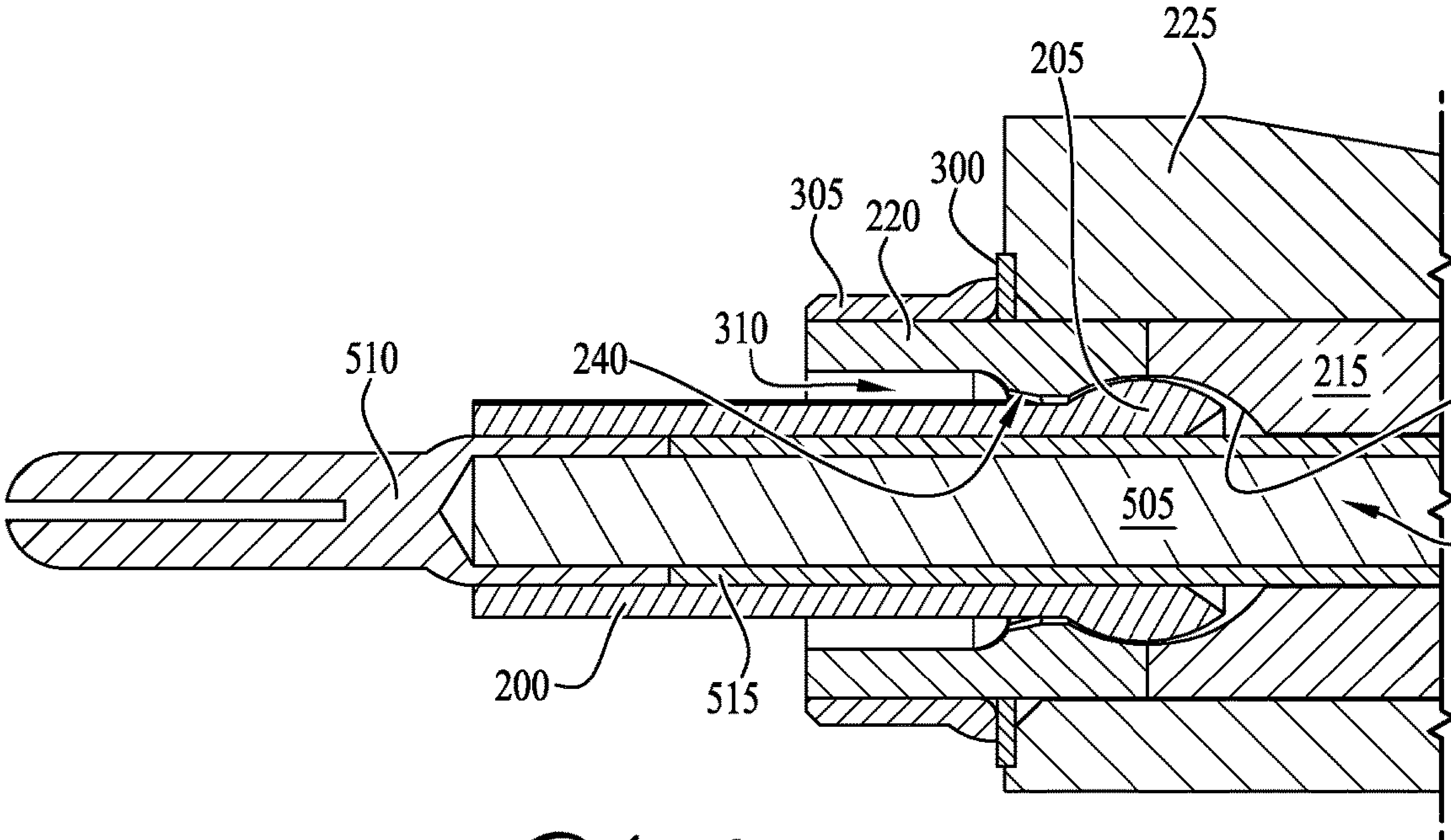

FIG. 16B

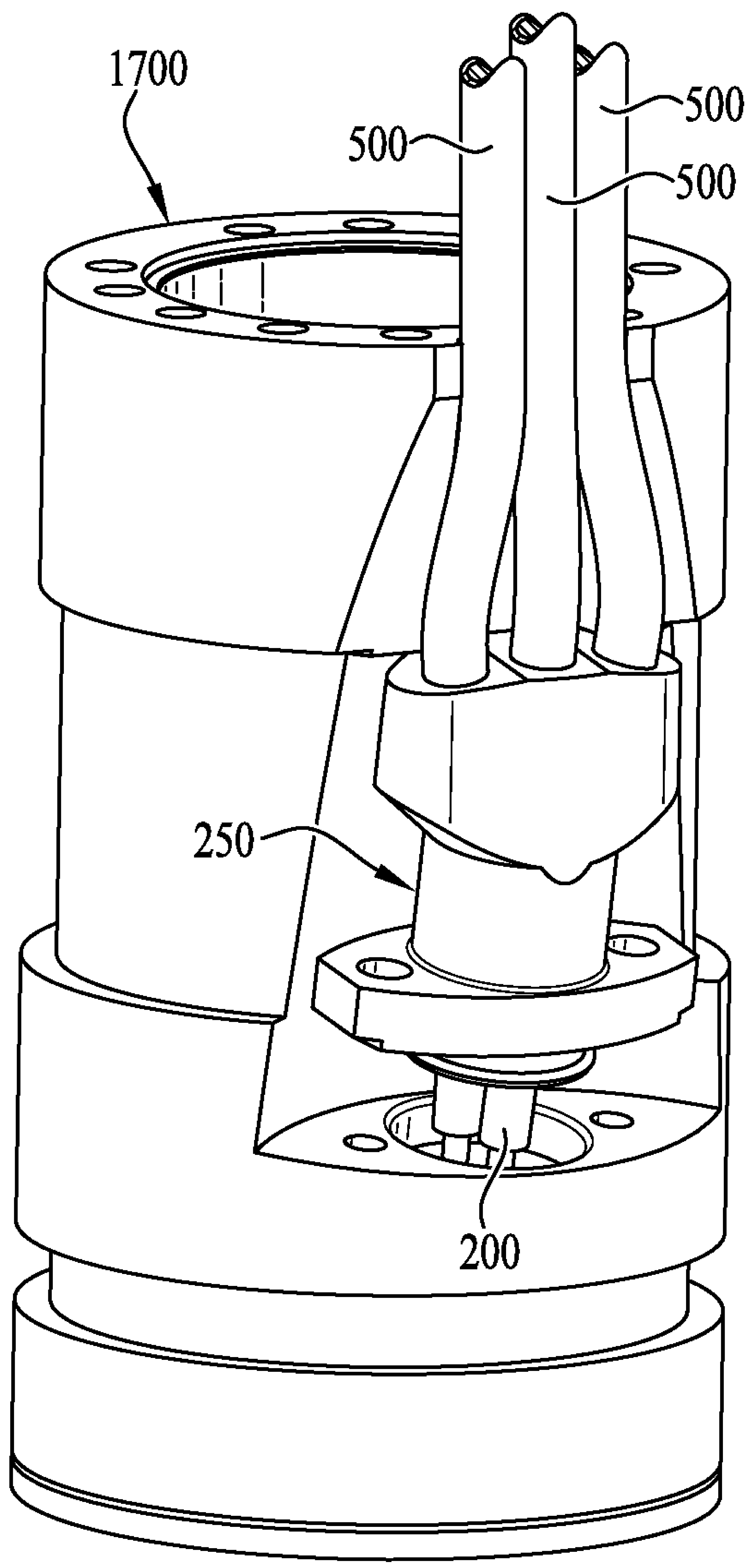

FIG. 17A

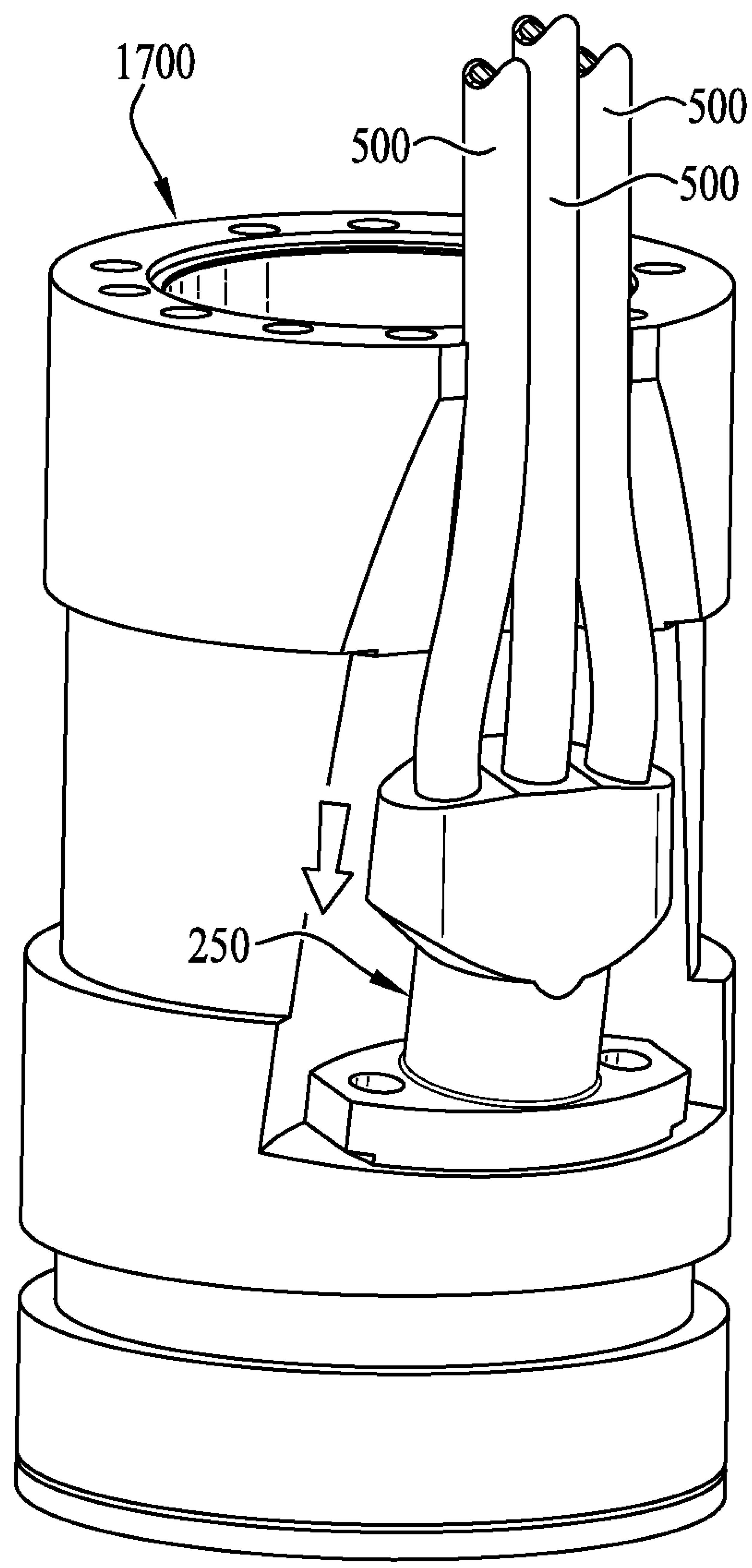

FIG. 17B

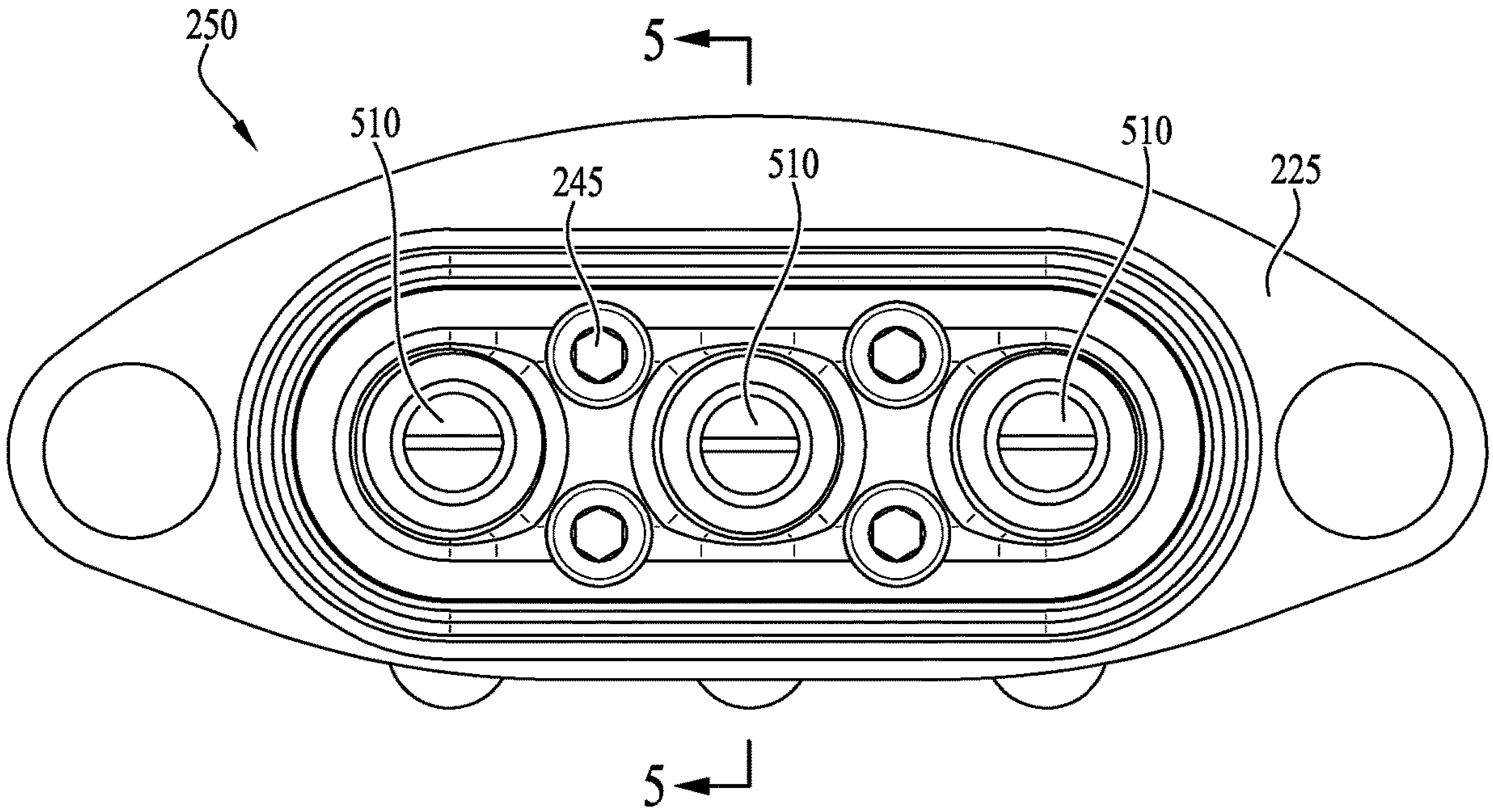

FIG. 18

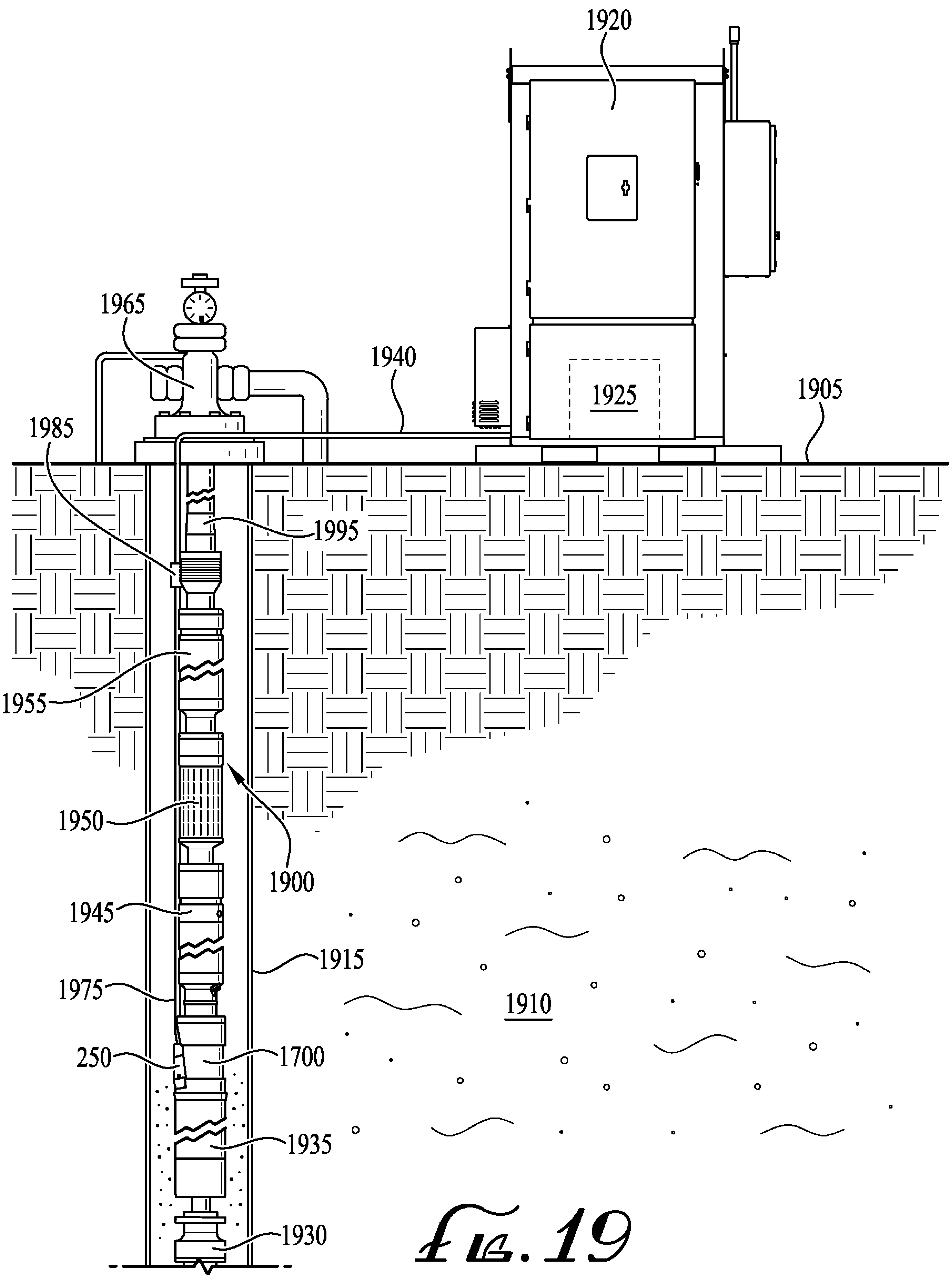
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FIG. 19

POTHEAD RETAINING SLEEVE SYSTEM, APPARATUS AND METHOD

BACKGROUND

1. Field of the Invention

Embodiments of the invention described herein pertain to the field of electric submersible motor power cable connections. More particularly, but not by way of limitation, one or more embodiments of the invention enable a pothead retaining sleeve system, apparatus and method.

2. Description of the Related Art

Fluid, such as natural gas, oil or water, is often located in underground formations. When pressure within a well is not enough to force fluid out of the well, the fluid must be pumped to the surface so that it can be collected, separated, refined, distributed and/or sold. Centrifugal pumps are typically used in electric submersible pump (ESP) applications for lifting well fluid to the surface. Centrifugal pumps accelerate a working fluid through a rotating impeller, which is driven by a rotating shaft.

The shaft's rotation is powered by an electrical motor typically located on an upstream side of a pump assembly. The motor is conventionally a two-pole, three-phase squirrel cage induction motor. The ESP power source is located at the surface of the well and is connected to the motor by insulated electrical conductors that extend up to thousands of feet alongside the ESP assembly down into the wellbore. A motor lead extension (MLE) cable, also referred to as a motor flat, is a low-profile cable that is spliced to the lower end of the main power cable, banded to the side of the ESP pump and seal-chamber section, and has a male termination for plugging or splicing into the motor electrical connection. An MLE typically has three leads or "phases." At a connection point to the motor, the MLE phases extend through a protected electrical connector that engages with an electrical receptacle on the motor. The electrical connector is sometimes referred to in the art as a "pothead," named after the potted or encapsulated conductors inside the electrical connector.

Well fluid should not contact the motor's electrical cables or electrical connections to avoid failure of the cables providing power to the motor. Failure of the power cables may cause inadequate power to the motor and failure of the motor. A conventional pothead includes a corrosion-resistant steel body filled with a number of insulating materials used within, including, for example, Polyether Ether Ketone (PEEK), an opaque organic thermoplastic polymer, which insulates the motor's electrical connections. FIG. **1** illustrates a cross section of a pothead of the prior art. Conventional pothead **100** may be made of lead in order to prevent harmful gas such as H_2S from permeating into motor electrical connections inside conventional pothead **100**. Three conventional phases **105** are typically arranged inside conventional pothead **100**. In any typical configuration, a conventional insulator **110** surrounds the phases to provide electrical integrity.

To install the power cable to the motor, the installer plugs each MLE phase into the connectors of the motor head, metal to metal. Next, the installer typically seals the connectors with insulating material such as polytetrafluoroethylene (PTFE) or the polyimide tape known as Kapton® (a registered trademark of E. I. du Pont de Nemours and Company of the United States). Finally, the installer pushes the connectors into the motor head and seals the connection. The installer inserts the ESP motor cables into conventional pothead **100** by pushing each conventional phase **105**, one at a time, into conventional insulator **110** in conventional pothead **100**. To make this process easier, pothead conventional insulator **110** has a conventional retaining sleeve **115** for each conventional phase **105**. In addition to its insulating properties, conventional retaining sleeve **115** must be rigid to aid in pushing the phase connectors into the motor head.

While various embodiments of potheads offer different configurations for the three phases, all suffer from a lack of space between the respective retaining sleeves for the installer to connect and tape the phases. The space between the phases is at a premium and restricted to accommodate the size of the motor head and the size of the power cable, which is often limited by the size of the annulus surrounding the assembly. Further, at the end of the pothead installation process the installer must gather the phases together and wrap them in additional insulation to save space and form a single MLE. Therefore, the retaining sleeves must be very close together. Unfortunately, this results in the space between each sleeve being inadequate to allow for properly tying-off each phase. In an attempt to work around this problem, installers tend to bend the sleeves to the side, two at a time, to have room to tie off each phase. However, bending the phases in this manner creates stress points **120** in the insulators as shown in FIG. **1**. Stress points **120** due to bending the rigid retaining sleeves create a potential for cracking, eventual cable damage and even cable failure over time. Where damage occurs to the insulator, the electrical connectors may be left vulnerable to ingress of unwanted fluids. Stress points **120** are particularly troublesome with multi-wire cable bundles.

As is apparent from the above, current electrical pothead connections do not provide sufficient space for an installer to tie-off the motor phases without risk of stress and/or damage to the phases and pothead insulator. Therefore, there is a need for an improved pothead retaining sleeve system, apparatus and method.

SUMMARY

A pothead retaining sleeve apparatus, system and method is described. Illustrative embodiments generally relate to a pothead pivoting retaining sleeve.

An illustrative embodiment of an electric submersible motor pothead includes a pair of insulating blocks including a first insulating block adjacent to a second insulating block, each pair of insulating blocks including a conduit for each phase of a plurality of phases of a power cable, each conduit including a socket formed partially by the first insulating block and partially by the second insulating block, a phase retaining sleeve extending through each conduit, the phase retaining sleeve including a ball seated in the socket and the phase retaining sleeve pivotable in the socket around the ball. In some embodiments, the phase retaining sleeve is pivotable by pitch, yaw and roll around the ball. In certain embodiments, the phase retaining sleeve further includes a tubular portion coupled to the ball, and a channel extending through the ball and the tubular portion of the retaining sleeve. In some embodiments, a power cable phase of the plurality of phases extends through the channel, the power cable phase powering an electric submersible motor. In some embodiments, the channel at a top of the ball includes a cutout around the power cable phase. In certain embodiments, each conduit further includes a tolerance extending from the socket, the tolerance accommodating angling of the

phase retaining sleeve inside the pair of insulating blocks. In some embodiments, the tolerance includes a flared inner diameter of one of the first insulating block or the second insulating block. In certain embodiments, the tolerance includes a space around a tubular portion of the retaining sleeve. In some embodiments, each phase retaining sleeve is independently pivotable. In certain embodiments, the conduits are arranged in a triangular configuration and the pair of insulating blocks are round in cross-section. In some embodiments, the electric submersible motor pothead further includes a pothead housing, the pothead housing including a seal skirt extending below the pair of insulating blocks. In certain embodiments, the conduits are arranged in a side-by-side configuration and the pair of insulating blocks are elliptical.

An illustrative embodiment of an electric submersible motor pothead includes a plurality of pivotable retaining sleeves, each pivotable retaining sleeve of the plurality of pivoting retaining sleeves including a ball that seats within a socket inside the electric submersible motor pothead, the ball rotatable in the socket such that each pivotable retaining sleeve is independently moveable around a spheroidal joint formed by the ball and socket. In some embodiments, each pivotable retaining sleeve of the plurality of pivoting retaining sleeves further includes a tubular portion coupled to the ball, and a channel extending through an inside of the tubular portion and the ball, wherein a phase of a power cable extends through the channel before connecting to an electric submersible motor. In certain embodiments, the channel extending through the ball includes an outwardly extending cutout forming a clearance for the phase as the ball rotates in the socket. In some embodiments, there are three phases connected to the electric submersible motor and three pivotable retaining sleeves in the plurality of pivotable retaining sleeves. In certain embodiments, the socket is formed by at least one block inside a housing of the pothead, wherein phases of a power cable extend through conduits in the block. In certain embodiments, each socket forms a portion of the conduit. In some embodiments, the at least one block is made of an insulating material. In some embodiments, the at least one block is made of a steel. In certain embodiments, there are at least two blocks aligned to form each conduit, and each of the at least two blocks forms a portion of the socket.

An illustrative embodiment of an electric submersible motor pothead includes a pothead for electrically connecting a power cable to an electric submersible motor, the power cable including a plurality of phases, each phase of the plurality of phases extending through a retaining sleeve, the retaining sleeve extending through a conduit formed through an insulating block secured inside the pothead, the conduit including a substantially spherical socket, the retaining sleeve including a tubular portion and a ball at an end of the tubular portion, the ball seated within the substantially spherical socket to form a ball and socket joint, and the tubular portion rotatable inward and outward around the ball and socket joint during tying off of the plurality of phases. In some embodiments, each phase of the power cable includes a conductor surrounded by a cable insulation layer, wherein the conductor is electrically coupled to a conducting pin that plugs into an electric submersible motor. In certain embodiments, the electric submersible motor is downhole and is operable to turn an electric submersible pump, and wherein the power cable extends from a power source proximate a well surface to the electric submersible motor to provide power to the electric submersible motor. In some embodiments, the ball is a spherical segment, and the socket is rounded to mate with the spherical segment. In certain embodiments, a diameter of the spherical segment is larger than a diameter of the tubular portion. In some embodiments, wherein a ratio of the diameter of the spherical segment to the diameter of the tubular portion is 1.23:1 and the retaining sleeve is rotatable outwards up to 35°.

An illustrative embodiment of an electric submersible motor power cable insulating apparatus, the insulating apparatus fitting within a pothead, the apparatus including a plurality of pivoting insulating sleeves, each pivoting insulating sleeve including an axially oriented shaft for accepting a power cable phase of an electric submersible pump (ESP) power cable, includes a ball joint terminating one end of the axially oriented shaft, and a central conduit traversing the length of the axially oriented shaft and ball joint, the central conduit mateable with the power cable phase, a first insulating block having a plurality of pathway openings on a first face, each opening accommodating a pivoting insulating sleeve, and a second face opposite the first face, the second face including a portion of a spherical cavity accommodating a portion of the ball joint, the opening contiguous with the portion of the spherical cavity of the first insulating block to form a pathway through the first insulating block, and a second insulating block having a first face including a cable access opening accessing the pathway through the first insulating block and a second face opposite the first face, the second face including a portion of the spherical cavity that accommodates a remaining portion of the ball joint such that when the second face of the first insulating block and the second face of the second insulating block are joined, the two second faces form a spherical cavity mateable to the ball joint of the pivoting insulating sleeve. In some embodiments, each pivoting retaining sleeve rotates up to 35° from a longitudinal axis of the pothead within the pathway opening. In certain embodiments, the pathway opening is tapered.

An illustrative embodiment of a method of installing a three-phase power cable into an electric submersible pump (ESP) motor head, includes splicing the three-phase power cable to expose three separate phases, placing a terminating end of each phase, one at a time, into a central conduit of an upper insulator within a pothead, passing the each phase, one at a time, through a ball joint at one end of a pivoting retaining sleeve and continuing on through an axial portion of the pivoting retaining sleeve thereby passing through a lower insulator, creating a space to connect the terminating end of a first phase of the three separate phases to a terminal connector of the ESP motor head by bending the terminating ends of a second and third phase away from the first phase by pivoting the pivoting retaining sleeve up to 35° from a central axis passing through the center of the pivoting retaining sleeve, connecting the terminating end of the first phase to a terminal connector of the ESP motor head, tying the terminating end of the first phase to the terminal connector of the ESP motor head by wrapping the connection in insulating material, repeating creating a space, connecting and tying the terminating end steps for each of the second and third phases in turn until all three phases are tied to the ESP motor head, pushing the pothead into the motor head, and sealing the pothead to motor head connection.

In further embodiments, features from specific embodiments may be combined with features from other embodiments. For example, features from one embodiment may be combined with features from any of the other embodiments.

In further embodiments, additional features may be added to the specific embodiments described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the present invention may become apparent to those skilled in the art with the benefit of the following detailed description and upon reference to the accompanying drawings in which:

FIG. **1** illustrates a cross-sectional view of a traditional insulator and prior art retaining sleeve of a conventional pothead.

FIG. **2**A is a cross-sectional view across line **2**A-**2**A of FIG. **12** of an exemplary pothead assembly showing pivoting retaining sleeves of an illustrative embodiment in a round configuration.

FIG. **2**B is a cross-sectional view across line **2**B-**2**B of FIG. **13** of an exemplary pothead assembly showing pivoting retaining sleeves of an illustrative embodiment pivoted outward.

FIGS. **3**A and **3**B are cross-sectional views of an exemplary pothead assembly showing pivoting retaining sleeves of an illustrative embodiment in a side-by-side configuration.

FIG. **4**A illustrates a side view of a pivoting retaining sleeve of an illustrative embodiment.

FIG. **4**B illustrates an orthogonal view of a pivoting retaining sleeve of an illustrative embodiment.

FIG. **4**C is a cross sectional view across line **4**C-**4**C of FIG. **4**A of a pivoting retaining sleeve of an illustrative embodiment.

FIG. **5** illustrates a cross-sectional view across line **5**-**5** of FIG. **18** of a pothead assembly of illustrative embodiments including an exemplary cable phase and terminal pin.

FIG. **6** illustrates a perspective view of a lower insulator having ball joint sockets of an illustrative embodiment.

FIG. **7** illustrates an exploded view of a pothead assembly with three pivoting retaining sleeves of an illustrative embodiment.

FIG. **8** illustrates a perspective view of a plurality of pivoting retaining sleeves installed in a lower insulator of an illustrative embodiment.

FIG. **9** illustrates a perspective view of placement of an upper insulator over a plurality of pivoting retaining sleeves of an illustrative embodiment.

FIG. **10** illustrates a perspective view of a plurality of pivoting retaining sleeves extending through an upper and lower insulator of an illustrative embodiment.

FIG. **11** illustrates a bottom view of a plurality of pivoting retaining sleeves encapsulated within an upper and lower insulator of an illustrative embodiment.

FIG. **12** illustrates an orthogonal view of a pothead assembly with three pivoting retaining sleeves of an illustrative embodiment in a round configuration.

FIG. **13** illustrates a bottom view of a pothead assembly with three retaining sleeves pivoted outward in an illustrative embodiment.

FIG. **14** illustrates an orthogonal view of a pothead assembly with all three retaining sleeves pivoted inward in an illustrative embodiment.

FIG. **15**A-**15**B illustrate a pothead housing of an illustrative embodiment for a side-by-side configuration of phases.

FIGS. **16**A and **16**B illustrate a cross-section of an exemplary pothead assembly showing a pivoting retaining sleeve with a cable and terminal pin of an illustrative embodiment.

FIGS. **17**A-**17**B are perspective views of a pothead of an illustrative embodiment being installed into a motor head.

FIG. **18** illustrates a planar view of a pothead assembly with terminal pins of an illustrative embodiment.

FIG. **19** is a perspective view of an electric submersible pump (ESP) assembly employing a pothead of an illustrative embodiment.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and may herein be described in detail. The drawings may not be to scale. It should be understood, however, that the embodiments described herein and shown in the drawings are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION

A pothead retaining sleeve apparatus, system and method are described. In the following exemplary description, numerous specific details are set forth in order to provide a more thorough understanding of embodiments of the invention. It will be apparent, however, to an artisan of ordinary skill that the present invention may be practiced without incorporating all aspects of the specific details described herein. In other instances, specific features, quantities, or measurements well known to those of ordinary skill in the art have not been described in detail so as not to obscure the invention. Readers should note that although examples of the invention are set forth herein, the claims, and the full scope of any equivalents, are what define the metes and bounds of the invention.

As used in this specification and the appended claims, the singular forms "a", "an" and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to a retaining sleeve includes one or more retaining sleeves.

"Coupled" refers to either a direct connection or an indirect connection (e.g., at least one intervening connection) between one or more objects or components. The phrase "directly attached" means a direct connection between objects or components.

"Downstream" refers to the longitudinal direction with the principal flow of lifted fluid through the wellbore when the pump assembly is in operation. By way of example but not limitation, in a vertical downhole electric submersible motor, the downstream direction may be towards the surface of the well.

"Upstream" refers to the longitudinal direction opposite the principal flow of lifted fluid through the wellbore when the pump assembly is in operation. By way of example but not limitation, in a vertical downhole electric submersible motor, the upstream direction may be opposite the surface of the well.

As used in this specification and the appended claims, with respect to a pothead assembly, the "bottom" of the pothead or a pothead component means the side of the pothead or pothead component closest to the motor when the pothead is installed, without regard to whether the well in which the pothead is installed is vertical, horizontal or extends through a radius.

As used in this specification and the appended claims, with respect to a pothead assembly, the "top" of the pothead or a pothead component means the side of the pothead or pothead component opposite the bottom of such pothead or pothead component.

As used herein, the term "outer," "outside" or "outward" means the radial direction away from the center of an electric submersible pump (ESP) power cable phase and/or the opening of a component through which the phase would extend. In the art, "outer diameter" and "outer circumference" are sometimes used equivalently. As used herein, the term outer diameter is used to describe what might otherwise be called the outer circumference or outer surface of a pothead component such as a retaining sleeve or insulator block.

As used herein, the term "inner", "inside" or "inward" means the radial direction toward the center of the ESP power cable phase and/or the opening of a component through which the phase would extend. In the art, "inner diameter" and "inner circumference" are sometimes used equivalently. As used herein, the term inner diameter is used to describe what might otherwise be called the inner circumference or inner surface of a pothead component such as a pothead housing or seal skirt, or the inner surface that forms a conduit through an insulating block.

As used herein the terms "axial", "axially", "longitudinal" and "longitudinally" refer interchangeably to the direction extending along the length of a pothead from bottom to top, or vice versa.

As used in this specification and the appended claims, "insulator block" or "insulating block" refer interchangeably to a block inside a pothead housing that surrounds the electrical connections' retaining sleeves inside the pothead. Although conventionally the "insulator block" or "insulating block" would have been made of an insulating material such as rubber or polyether ether ketone (PEEK), illustrative embodiments are not so limited and include an insulator block or insulating block made of corrosion resistant steel or another similar conductive material without regard to insulating properties.

For ease of description, the illustrative embodiments described herein are described in terms of an ESP assembly making use of a three-phase motor and power cable. However, the pothead of illustrative embodiments is not so limited and may be applied to any motor, with any number of phases, exposed to fluid and having a motor plug-in, splice-in, tape-in or similar electrical connection. For example, the retaining sleeve of the illustrative embodiments may be applied to submersible motors in axial-flow pumps, radial-flow pumps, mixed-flow pumps, horizontal surface pumps, and/or turbine regenerative type pumps and/or to electric motors operating other types of machines that may be submerged.

Illustrative embodiments provide a pivotable pothead retaining sleeve that terminates at a ball joint. Each retaining sleeve may be encased in a cylindrical space formed by an insulator, the space having a rounded socket. The ball joint of the retaining sleeve may rest in the socket. A power cable and/or power cable phase may extend through the retaining sleeve. The ball joint may pivot in the socket to permit the retaining sleeve to rotate and/or swivel around the ball joint without putting undesirable stress on the insulator or power cable. Illustrative embodiments may provide a pivoting retaining sleeve to improve installation of an ESP motor's electrical power without creating compressive force on the phases when an installer bends the phases to allow for proper tie-in. Illustrative embodiments may reduce or eliminate stress points and/or cracking of pothead insulation, which may reduce the instance of cable damage or failure. Illustrative embodiments may provide space and/or movement for an installer to tie-off the phases without risk of stress and/or damage to the phases and possibly cracking the insulators.

In a three-phase motor, such as an ESP induction motor, the three cable phases may be included in the pothead of one or more illustrative embodiments. For ease of description, the pothead of illustrative embodiments may be described in terms of enclosing three phases in either a side-by-side or round configuration, however, other configurations may be employed depending on the number and size of phases and space limitations.

FIG. **2**A and FIG. **2**B illustrate a pothead with pivoting retaining sleeves of an illustrative embodiment arranged in a round phase configuration. Retaining sleeve **200** may be tubular in shape with ball **205** on the upper side of sleeve **200**. Ball **205** may generally be spherical in shape although ball **205** may not form a complete sphere, for example ball **205** may be a spherical segment, spheroid and/or ellipsoid. As shown in FIG. **2**A and FIG. **2**B, ball **205** is a spherical segment, cut by a plane at its top to allow phase **500** (shown in FIG. **5**) to extend through ball **205**, and cut by a plane at its bottom so as to be continuous with tubular portion **400** (shown in FIG. **4**A). Socket **210** may be a two-part socket formed partially by upper insulating block **215** and partially by lower insulating block **220**. Socket **210** may be a cavity generally spherical or ellipsoid in shape, but may not form a complete sphere and/or may be complementary to the shape of ball **205**. Ball **205** and socket **210** may mate and/or be complementary in shape such that rounded portion of ball **205** rocks within rounded socket **210** as retaining sleeve **200** pivots, rotates, rolls and/or moves in the joint. Ball **205** of retaining sleeve **200** may sit within socket **210** and be rotatable and/or pivotable inside socket **210** to form pivotable retaining sleeve **200**.

Housing **225** of pothead **250** may include seal skirt **230** that extends below lower insulating block **220**. Seal skirt **230** may seal the motor connection from fluid ingress. In FIG. **2**A, retaining sleeve **200** is shown parallel to longitudinal axis **255**. In FIG. **2**B, retaining sleeves **200** have been rotated outwards an angle θ around pivot point **235**. Ball **205** and socket **210** joint may allow rotation around three axes (pitch, yaw and roll) about the common pivot point **235**, although seal skirt **230** and/or lower insulating block **220** may restrict angle θ and/or the range of motion of retaining sleeve **200**. As shown in FIG. **2**B, seal skirt **230** may limit the rotation of retaining sleeve **200** inside socket **210** as retaining sleeve **200** rotates to abut the inner diameter of seal skirt **230** and/or the inner diameter of tolerance **240**. Tolerance **240** may be an outward flare of the inner diameter of the conduit through lower insulating block **220**, below socket **210**, that accommodates angling of retaining sleeve **200** as shown in FIG. **2**B. Screws **245** may compress upper insulating block **215** and lower insulating block **220** together. Upper insulating block **215** and/or lower insulating block **220** may be made of insulating material such as Polyether Ether Ketone (PEEK), rubber, ceramic, phenolic resin, thermal plastic or another similar insulating material. In some embodiments, upper insulating block **215** and/or lower insulating block **220** may be conductive and may be made of metal, such as steel.

FIG. **3**A and FIG. **3**B illustrate a pothead with pivoting retaining sleeves of an illustrative embodiment showing a side-by-side (linear) phase configuration. Round and/or spherical socket **210** may be formed partially by upper insulating block **215** and partially by lower insulating block **220**. For example, each insulating block **215**, **220** may form half of socket **210** and/or spherical socket **210** may be formed ⅓ by a first insulating block and ⅔ by the second block. In certain embodiments, socket **210** may be formed in a single insulating block. Ball **205** of retaining sleeve **200** seats within socket **210** and may be pivotable and/or rotatable therein. In the example of FIG. **3**A and FIG. **3**B, lower insulator **220** extends beyond and/or below (lower than) pothead housing **225**, and the lower insulator **220** may limit the maximum angle θ of rotation of retaining sleeve **200**. A lead gasket **300** surrounded by an elastomeric boot **305**, which may be a molded seal made of rubber such as ethylene propylene diene monomer (EPDM) or Aflas® (a registered trademark of Asahi Glass Co. of Japan), may seal the space between the outer diameter of lower insulator **220** and the inner diameter of housing **225**. In FIG. **3**A, retaining sleeves **200** are parallel to longitudinal axis **255**. In FIG. **3**B, the retaining sleeve **200** has been rotated outward an angle θ. The side-by-side embodiment of FIGS. **3**A and **3**B may be compared and contrasted with the round and/or triangular embodiment shown in FIGS. **2**A and **2**B.

FIGS. **4**A-**4**C illustrate a pivoting retaining sleeve of illustrative embodiments. Retaining sleeve **200** may generally be rigid and tubular in shape, and may be made of polyetheretherketone (PEEK), rubber, ceramic, phenolic, thermoplastic or another non-conductive material having similar properties. An end of sleeve **200** may include ball **205** that pivots within socket **210**, to form a ball and socket and/or spheroidal joint. The ball and socket joint may permit retaining sleeve **200** with phase **500** (shown in FIG. **5**) extending through retaining sleeve **200**, to pivot during installation of phases **500** and connection of pothead assembly **250** to motor head **1700** (shown in FIG. **17**A). Tubular portion **400** (body) of pivotable retaining sleeve **200** may be about ¾ (or 75%) of the length of retaining sleeve **200**. Tubular portion **400** may be tubular, annular and/or shaped like a hollow cylinder. Ball joint **205** may form one end of pivoting retaining sleeve **200**. Ball **205** may be a rounded, ellipsoid and/or spherical bulb and/or protrusion at one end of retaining sleeve **200**.

Ball **205** may have a larger diameter than the diameter of tubular portion **400** such that ball **205** stays locked and/or does not slide out from socket **210**. The ratio of the diameter of ball **205**, the diameter of the sphere of which ball **205** forms a segment, and/or the largest diameter of ball **205** as compared to the diameter of tubular portion **400** may determine the angle, degrees and/or extent of pivot of retaining sleeve **200**. For example, to achieve a 35° cone **800** (shown in FIG. **8**) of movement, the ratio between the diameter of tubular portion to the diameter of ball **205** (e.g., the diameter of the sphere from which ball **205** is cut) is 1:1.23.

Axial opening **405** may extend the length of pivoting retaining sleeve **200** from tubular end **410** through ball **405**. Axial opening **405** may terminate in a similarly sized opening in the base of ball joint **205**, but include tapered cutout **415**, and permit phase **500** to extend through the length of retaining sleeve **200**. Illustrative embodiments may accommodate diameter variations in the power cables **1940** (shown in FIG. **19**) and phases **500**. Exemplary power cables **1940** of illustrative embodiments may vary from ⅛" (3.175 mm) to ¼" (6.35 mm), though illustrative embodiments are not so limited. Depending on the cable diameter, the diameter and/or thickness of the pivoting retaining sleeves **200** and their associated ball sockets **210** may vary to maximize effectiveness. In an exemplary, non-limiting example phase **500** may have a diameter of ¼ inch (6.35 mm), pivoting retaining sleeve ball **205** may have a radius of about 0.245" (6.223 mm), and sleeve **200** may be about 1.260" (3.2 cm) in length. In this example, pothead assembly **250** may be about 4.2 inches (10.668 cm) in length.

Ball **205** and/or axial opening **405** may include cutout **415**, as illustrated in FIG. **4**C. Cutout **415** may be a notch, angling outward and/or clearance around opening **405** extending through the top of ball **205**. Cutout **415** may ensure that as retaining sleeve **200** pivots with phase **500** extending through opening **415** of retaining sleeve **200**, retaining sleeve **200** does not cut into phase **500** and/or retaining sleeve does not otherwise damage phase **500**. FIG. **5** illustrates a cross-sectional view of the pothead assembly **250** including phase **500** extending through pothead **250** and retaining sleeve **200**. Conductor **505** of phase **500** terminates at terminal pin **510**. Cable insulation **515** may terminate prior to terminal pin **510** to allow conductor **505** to contact terminal pin **510**. Cutout **415** provides a clearance around phase **500** as phase **500** extends through ball **205**, to permit retaining sleeve to rotate without piercing phase **500**.

FIG. **6** illustrates an orthogonal view of a pothead upper insulator showing ball joint sockets of an illustrative embodiment. Upper insulator **215** may have a variety of cross-sectional shapes such as elliptical or round. The portion of socket **210** formed by upper insulator **215** is shown. Apertures **600** may be for compression screws **245** to attach upper insulator **215** to lower insulator **220** when pothead **250** is assembled. In round phase **500** configurations, upper insulator **215** may have a circular or similarly rounded cross-section as shown in FIG. **7**, for example. Whether sleeves **200** are in a round, side-by-side, or other configuration, retaining sleeves **200** of illustrative embodiments may operate in a substantially similar manner. As shown in FIG. **7**, sockets **210** and/or conduits extending through upper insulating block **215** and lower insulating block **220** may extend through the insulating blocks **215**, **220** from a first face through to the opposing face of each block **215**, **220**. In FIG. **8**, three pivoting retaining sleeves **200** are shown in a side-by-side configuration in an elliptically-shaped insulating block **215** that may be installed into pothead housing **225**.

Each phase **500** of a motor **1935** (shown in FIG. **19**) powered by cable **1940** may require one pivoting retaining sleeve **200**. Upper insulator **215** may have the rounded and/or spherical ball socket (cavity) **210** or a portion thereof for each of the pivoting retaining sleeves **200** as illustrated in FIG. **8**. In some embodiments, for ease of illustration and so as not to obscure illustrative embodiments, this description assumes a three-phase embodiment, though illustrative embodiments are not so limited. Thus, upper insulator **215** of FIG. **8** shows three ball sockets **210**. Each insulating block **215**, **220** may form a portion, one-half, or about one-half the space that forms socket **210**, receives ball joint **205** and/or provides the common center **235** around which ball joint **205** may pivot. The other portion of socket **210** may be formed in lower insulator **220**. The ball sockets **210** in upper insulator **215**, lower insulator **220** and/or a combination thereof, are of largely identical and sufficient size to encompass ball joint **205**, with enough tolerance to allow ball joint **205** to rotate and/or pivot as described herein.

FIG. **8** illustrates three pivoting retaining sleeves **200** installed in upper insulator **215** of an illustrative embodiment. Central axis **255** may be a line parallel to the axial direction of the retaining sleeve **200** and/or the longitudinal direction through pothead **250**. Angle θ may indicate a cone **800** of rotation around central axis **255** with angle θ being an angle of offset from central axis **255**. Cone **800** may proscribe the degrees of freedom of each pivoting retaining sleeve **200**. Where tubular portion **400** of retaining sleeve

200 abuts lower insulating block 220 or skirt seal 230 when angled, angle θ may be about 20°, 30°, 35° or 40° from central axis 255. Once positioned at about angle θ from central axis 255, retaining sleeve 200 may pivot, rotate, and/or swivel along cone 800 and/or may be repositioned through yaw, pitch or roll, as needed. Each of the pivoting retaining sleeves 200 may rotate independently of one another, such that an installer may push two sleeves 200 in one direction and a third may be pulled in another, creating room for the installer to tie-in each phase 500 of power cable 1940 one phase 500 at a time. Sleeves 200 may move independently from one another, each sleeve 200 rotating in a distinct direction.

FIG. 9 illustrates placement and/or sliding of lower insulator 600 over a plurality of ball joint retaining sleeves 200. Lower insulator 220 may have elongate openings 900 of sufficient diameter to accommodate retaining sleeve 200, including pivoting of retaining sleeve as sleeve 200 leans in response to pivoting of ball joint 205. In side-by-side embodiments with three phases 500, the center retaining sleeve 200 may have an elongate opening 900 on each side and/or clearance 310 may extend between the inner diameter of lower insulating block 220 and the outer diameter of retaining sleeve 200. Lower insulator 220 may also include ball socket 210, the lower portion of ball socket 210 and/or a cylindrical opening terminating in a portion of ball socket 210, to accommodate retaining sleeve 200 and/or the lower portion of ball joint 205, with tolerances 240 to allow for independent rotation of each pivoting retaining sleeve 200 as described above. In some embodiments, elongate opening 900, tolerance 240 and/or clearance 310 may taper outwards (flare) at about 35° to allow pivoting retaining sleeve 200 to rotate on ball joint 320 a sufficient angle θ without obstruction to create room for installation of phases 500 into motor head 1700.

FIG. 10 illustrates a plurality of ball joint retaining sleeves 200 encapsulated within upper insulator 215 and lower insulator 220 of an illustrative embodiment. Retaining sleeves 200 may extend through conduits and/or pathways extending through insulators 215, 220, and phases 500 may extend through retaining sleeves 200. In this exemplar, all three pivoting retaining sleeves 200 may be parallel to central axis 255. Tolerance 240 around each retaining sleeve 200 and/or adjacent to the bottom of socket 210 is shown in FIG. 11, which is a bottom view of lower insulator 220. Tolerance 240 may permit retaining sleeve 200 to angle away from axis 255. Apertures 600 in insulators 215, 220 may accommodate compression screws 245 that hold upper insulator 215 and lower insulator 220 together after assembly with pivoting retaining sleeve 200. FIG. 11 illustrates the manner in which ball 205 may seat within socket 210 of upper insulator 215 and lower insulator 220, with lower insulator sliding around retaining sleeves 200 to complete socket 210. Compression screws 245 may be employed to compress upper insulator and lower insulator 200 encasing retaining sleeves 200, together.

Returning to FIGS. 3A and 3B, socket 210 around ball 205 of pivoting retaining sleeve 200 may be a gap and/or a circular or rounded space formed by one of upper insulator 215, lower insulator 220 or both. In some embodiments, socket 210 may be contiguous with a conduit through insulating blocks that accommodates tubular portion 400 of retaining sleeve 200 and/or phase 500. Socket 210 may accommodate ball 205 and provide ball 205 freedom to rotate around pivot point 235 through and around cone 800. Ball 205 and socket 210 joint may provide an angle θ around axis 255, such as up to 30-40° from axis 255, allowing pivoting retaining sleeve 200 to rotate, roll, pivot and/or otherwise move out of the way, with motion around central axis 255 and/or pivot point 235, to allow an installer to tie-in other power cable phases 500. Ball 205 in socket 210 may permit motion around three axes such as pitch, yaw and roll, with a common center (pivot point 235). The angle and/or size of tolerance 240, clearance 310, lower insulating block 220, seal skirt 230 and/or the ratio between the outer diameters of ball 205 and tubular portion 400, may determine the range of motion of ball 205 and socket 210 joint. FIG. 3B shows pivoting retaining sleeve 200 rotated out of the way by engaging ball 205 and socket 210 joint. Each phase 500 may be moved inside pivoting retaining sleeve 200 in such manner which may reduce stress on lower insulator 220, sleeve 200 and/or phase 500.

Turning to FIG. 12, a “round” and/or in this instance where three phases 500 are employed, triangular configuration of phases 500 is shown in a round lower insulator 220, with all three pivoting retaining sleeves 200 parallel to axis 255. In the embodiment of FIG. 12, pothead 250 may be sealed to motor head 1700 (shown in FIG. 17A) with elastomeric ring 260 (shown in FIG. 2A) placed around skirt seal 230. FIG. 13 illustrates a bottom view of the triangular and/or round phase configuration of FIG. 12 with retaining sleeves 200 pivoted outward from axis 255 in a configuration that may give maximum access to all three phases 500 at once. Because of pivoting retaining sleeves 200, reduced stress may be placed on phase 500 and/or lower insulator 220, in this configuration, which may best accommodate the tie-in process. As shown in FIG. 13, phases in the triangular and/or round configuration may pivot until skirt seal 230 obstructs further pivot of retaining sleeve 200 and/or until offset is no longer desired.

FIG. 14 illustrates an orthogonal view of pothead assembly 250 with all three retaining sleeves 200 pivoted inward in one embodiment of the invention. This configuration of pivoting retaining sleeves 200 may allow gathering all three phases 500 together for additional insulation wrapping, as well as making the connection compact and therefore easier to push into motor head 1700 during installation. FIGS. 15A-15B illustrate additional views of pothead housing 225 of an illustrative embodiment for an elliptical insulator 215, 220 and/or a linear (side-by-side) arrangement of phases 500.

Turning to FIGS. 16A and 16B, a power cable phase 500 compatible with one or more embodiments of the invention may be an insulated electrical cable that includes conductor 505 surrounded by cable insulation 515. In some embodiments, the cable may contain multi-wire conductors 505 each wrapped in its own insulation 515 and then bound together as phase 500. Each motor lead extension (MLE) 1975 (shown in FIG. 19) may include three phases 500 for a three-phase, squirrel cage induction motor 1935. Conductor 505 may be copper or aluminum, for example. Cable insulation layer 515 may for example be Ethylene Propylene Diene Monomer (EPDM), rubber, polypropylene, polyethylene, or similar high temperature polymeric elastomer. In a three phase motor, such as ESP induction motor 1935, three phases 500 may be included in pothead assembly 250 of illustrative embodiments. Insulation layer 515 of power cable 1940 may be surrounded by an extruded lead sheath and/or armor (not shown) to protect cable insulation as it extends the length of ESP assembly 1900 downhole. A lead sheath and/or armor may terminate prior to extension and/or passing of phase 500 through retaining sleeve 200. Conducting pins 510 may extend from electrical conductor 505 and transfer current to motor 1935 through corresponding electrical receptacles in motor head **1700**. Pivoting retaining sleeves **200** of illustrative embodiments may enclose each phase **500** as it extends out the bottom of pothead **250**, and may allow an installer to beneficially maneuver each phase **500** during phase **500** tie-in. FIGS. **16**A and **16**B illustrate a cross-section of pothead assembly **250** showing pivoting retaining sleeve **200** with phase **500** and terminal pin **510** of an illustrative embodiment, with FIG. **16**A in a pivoted orientation and FIG. **16**B with phases **500** in a parallel orientation.

A method of installing the three-phase power cable **1940** into the ESP motor head **1700** includes the steps of splicing a three-phase power cable **1940** and/or MLE **1975** to expose three separate phases **500** of power cable **1940**. Next, the installer may place the terminating end of each phase **500**, one at a time, into the central conduit and/or top of socket **210** opening of upper insulator **215** within pothead housing **225**; passing each phase **500**, one at a time, through ball joint **205** at one end of pivoting retaining sleeve **200** and continuing on through tubular portion **400** of pivoting retaining sleeve **200** thereby passing through lower insulator **220**. To create enough space to connect the terminating end of a first phase **500** to a terminal connector of ESP motor head **1700**, the installer may bend the terminating ends of a second and third phase **500** away from the first phase **500** by pivoting the corresponding retaining sleeves **200**, for example up to 35° from central axis **255**. When the space is ready, the installer may connect the terminating end of the first phase **500** to a first terminal connector of ESP motor head **1700**. Next, the installer may tie the terminating end of the first phase **500** to the first terminal connector of ESP motor head **1700** by wrapping the connection in insulating material, such as, for example, Kapton® (a registered trademark of E. I. du Pont de Nemours and Company, a U.S. Delaware corporation) tape. This method is repeated by creating a space, connecting and tying the terminating ends for each of the second and third phases **500** and/or any additional phases **500** in turn until all phases **500** are tied to ESP motor head **1700**. Finally, the installer pushes pothead assembly **250** into motor head **1700** and seals pothead **250** to motor head **1700** connection with an O-ring or similar elastomeric retaining mechanism. FIG. **17**A and FIG. **17**B illustrate pothead **250** assembly having pothead housing **225** of an illustrative embodiment inserted into motor head **1700**. FIG. **18** illustrates a plan view of a pothead assembly **250** with terminal pins **155** installed of an illustrative embodiment. When all phases **500** are installed with their conductor **505** and terminal pins **510**, pothead assembly **250** may appear as seen in FIG. **18**.

FIG. **19** illustrates an ESP assembly having a pothead retaining sleeve of an illustrative embodiment. ESP assembly **1900** may be located downhole in a well below surface **1905** and may extend, for example, several hundred or a few thousand feet deep. ESP assembly **1900** may be vertical, horizontal or may be curved, bent and/or angled, depending on well direction. The well may be an oil well, water well, and/or well containing other hydrocarbons, such as natural gas, and/or another production fluid from underground formation **1910**. ESP assembly **1900** may be separated from underground formation **1910** by well casing **1915**. Production fluid may enter well casing **1915** through casing perforations (not shown). Casing perforations may be either above or below ESP intake **1950**.

ESP assembly **1900** may include, from bottom to top, downhole sensors **1930** which may detect and provide information such motor speed, internal motor temperature, pump discharge pressure, downhole flow rate and/or other operating conditions to a user interface, variable speed drive controller and/or data collection computer in cabinet **1920**. ESP motor **1935** may be an induction motor, such as a two-pole, three phase squirrel cage induction motor. Power cable **1940** may provide power to ESP motor **1935** and/or carry data from downhole sensors **1930** to surface **1905**. ESP cabinet **1920** at surface **1905** may contain a power source **1925** to which power cable **1940** connects. Downstream of motor **1935** may be motor protector **1945**, ESP intake **1950**, multi-stage centrifugal ESP pump **1955** and production tubing **1995**. Motor protector **1945** may serve to equalize pressure and keep the motor oil separate from well fluid. ESP intake **1950** may include intake ports and/or a slotted screen and may serve as the intake to centrifugal ESP pump **1955**. ESP pump **1955** may be a multi-stage centrifugal pump including stacked impeller and diffuser stages. Other components of ESP assemblies may also be included in ESP assembly **1900**, such as a tandem charge pump (not shown) or gas separator (not shown) located between centrifugal ESP pump **1955** and intake **1950** and/or a gas separator may serve as the pump intake. Shafts of motor **1935**, motor protector **1945**, ESP intake **1950** and ESP pump **1955** may be connected together (i.e., splined) and be rotated by motor **1935**. Production tubing **1995** may carry lifted fluid from the discharge of ESP pump **1355** towards wellhead **1965**.

Power cable **1940** may extend from power source **1925** at surface **1905** to motor lead extension (MLE) **1975**. Cable connection **1985** may connect power cable **1940** to MLE **1975**. MLE **1975** may plug in, tape in, spline in or otherwise electrically connect power cable **1940** to motor **1935** to provide power to motor **1935**. Pothead assembly **250** may enclose the electrical connection between MLE **1975** and head **1700** of motor **1935**. Power cable **1940** may deliver power to motor **1935** through electric conductor **505** making up one or more motor phases **500**.

A pothead retaining sleeve apparatus, system and method has been described. Illustrative embodiments may provide pivoting of the retaining sleeves during installation providing space to tie-in the power cable phases, such as the connections in an ESP assembly. Illustrative embodiments may provide an improved ability to install the phases into the motor head without creating undue stress on the phase cables and/or insulating blocks.

Further modifications and alternative embodiments of various aspects of the invention may be apparent to those skilled in the art in view of this description. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the general manner of carrying out the invention. It is to be understood that the forms of the invention shown and described herein are to be taken as the presently preferred embodiments. Elements and materials may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the invention may be utilized independently, all as would be apparent to one skilled in the art after having the benefit of this description of the invention. Changes may be made in the elements described herein without departing from the scope and range of equivalents as described in the following claims. In addition, it is to be understood that features described herein independently may, in certain embodiments, be combined.

The invention claimed is:

1. An electric submersible motor pothead comprising:

a pair of insulating blocks comprising a first insulating block adjacent to a second insulating block, each pair of insulating blocks comprising a conduit for each phase of a plurality of phases of a power cable;

each conduit comprising a socket formed partially by the first insulating block and partially by the second insulating block;

a phase retaining sleeve extending through each conduit, the phase retaining sleeve comprising a ball seated in the socket; and

the phase retaining sleeve pivotable in the socket around the ball.

2. The electric submersible motor pothead of claim **1**, wherein the phase retaining sleeve is pivotable by pitch, yaw and roll around the ball.

3. The electric submersible motor pothead of claim **1**, wherein the phase retaining sleeve further comprises a tubular portion coupled to the ball, and a channel extending through the ball and the tubular portion of the phase retaining sleeve.

4. The electric submersible motor pothead of claim **3**, wherein a power cable phase of the plurality of phases extends through the channel, the power cable phase powering an electric submersible motor.

5. The electric submersible motor pothead of claim **4**, wherein the channel at a top of the ball comprises a cutout around the power cable phase.

6. The electric submersible motor pothead of claim **1**, wherein each conduit further comprises a tolerance extending from the socket, the tolerance accommodating angling of the phase retaining sleeve inside the pair of insulating blocks.

7. The electric submersible motor pothead of claim **6**, wherein the tolerance comprises a flared inner diameter of one of the first insulating block or the second insulating block.

8. The electric submersible motor pothead of claim **6**, wherein the tolerance comprises a space around a tubular portion of the phase retaining sleeve.

9. The electric submersible motor pothead of claim **1**, wherein each phase retaining sleeve is independently pivotable.

10. The electric submersible motor pothead of claim **1**, wherein the conduits are arranged in a triangular configuration and the pair of insulating blocks are round in cross-section.

11. The electric submersible motor pothead of claim **10**, further comprising a pothead housing, the pothead housing comprising a seal skirt extending below the pair of insulating blocks.

12. The electric submersible motor pothead of claim **1**, wherein the conduits are arranged in a side-by-side configuration and the pair of insulating blocks are elliptical.

13. An electric submersible motor pothead system comprising:

a pothead for electrically connecting a power cable to an electric submersible motor, the power cable comprising a plurality of phases, each phase of the plurality of phases extending through a retaining sleeve;

the retaining sleeve extending through a conduit formed through an insulating block secured inside the pothead, the conduit comprising a substantially spherical socket;

the retaining sleeve comprising a tubular portion and a ball at an end of the tubular portion, the ball seated within the substantially spherical socket to form a ball and socket joint; and

the tubular portion rotatable inward and outward around the ball and socket joint during tying off of the plurality of phases.

14. The electric submersible motor pothead system of claim **13**, wherein each phase of the power cable comprises a conductor surrounded by a cable insulation layer, wherein the conductor is electrically coupled to a conducting pin that plugs into an electric submersible motor.

15. The electric submersible motor pothead system of claim **14**, wherein the electric submersible motor is downhole and is operable to turn an electric submersible pump, and wherein the power cable extends from a power source proximate a well surface to the electric submersible motor to provide power to the electric submersible motor.

16. The electric submersible motor pothead system of claim **13**, wherein the ball is a spherical segment, and the substantially spherical socket is rounded to mate with the spherical segment.

17. The electric submersible motor pothead system of claim **16**, wherein a diameter of the spherical segment is larger than a diameter of the tubular portion.

18. The electric submersible motor pothead system of claim **17**, wherein a ratio of the diameter of the spherical segment to the diameter of the tubular portion is 1.23:1 and the retaining sleeve is rotatable outwards up to 35°.

19. The electric submersible motor pothead system of claim **13**, wherein the retaining sleeve is pivotable by pitch, yaw and roll around the ball.

20. A method of installing a three-phase power cable into an electric submersible pump (ESP) motor head, comprising:

splicing the three-phase power cable to expose three separate phases;

placing a terminating end of each phase, one at a time, into a central conduit of an upper insulator within a pothead;

passing each phase, one at a time, through a ball joint at one end of a pivoting retaining sleeve and continuing on through an axial portion of the pivoting retaining sleeve thereby passing through a lower insulator;

creating a space to connect the terminating end of a first phase of the three separate phases to a terminal connector of the ESP motor head by bending the terminating ends of a second and third phase away from the first phase by pivoting the pivoting retaining sleeve up to 35° from a central axis passing through a center of the pivoting retaining sleeve;

connecting the terminating end of the first phase to a terminal connector of the ESP motor head;

tying the terminating end of the first phase to the terminal connector of the ESP motor head by wrapping the connection in insulating material;

repeating creating a space, connecting, and tying the terminating end steps for each of the second and third phases in turn until all three phases are tied to the ESP motor head;

pushing the pothead into the ESP motor head; and

sealing the pothead to motor head connection.

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